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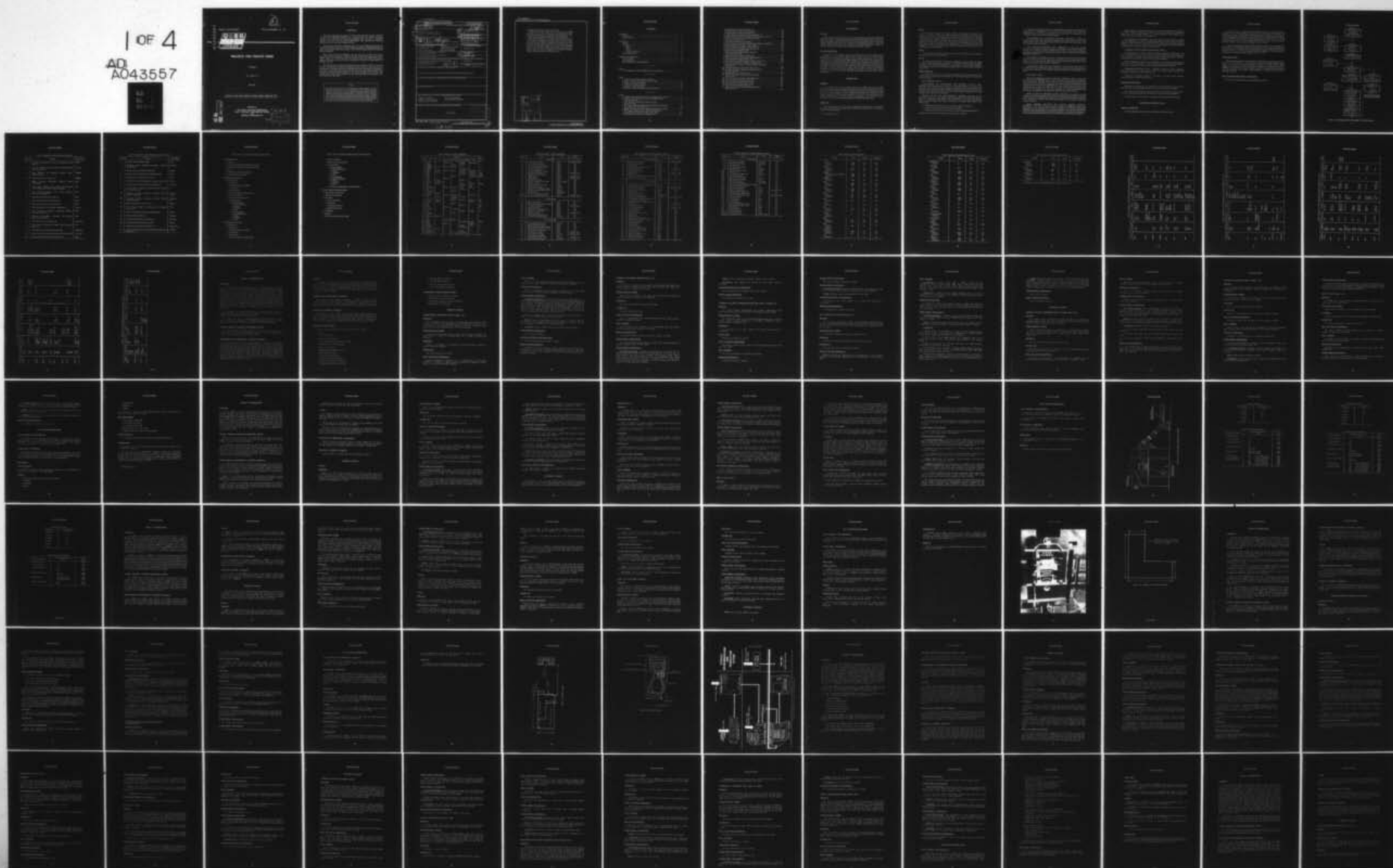

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JTCG/AS

BALLISTIC TEST FACILITY GUIDE

Final Report

B. E. Edney, et al.

May 1977

Prepared for

THE JOINT LOGISTICS COMMANDERS
JOINT TECHNICAL COORDINATING GROUP
ON
AIRCRAFT SURVIVABILITY

FOREWORD

This report summarizes the results of research performed under contracts DAAG46-75-C-0027 and DAAG46-76-C-0009. The contractors were The BDM Corporation, Vienna, VA, and RMC Research Corporation, Bethesda, MD. The work was conducted between 1974 and 1975. Dr. R. Chait, DRXMR-MP, Army Materials and Mechanics Research Center, was the Project Manager/Monitor.

The work was sponsored by JTCG/AS as part of a 3-year TEAS (Test and Evaluation Aircraft Survivability) Program. The TEAS Program was funded by DDR&E/ODDT&E. The effort was conducted under the direction of the JTCG/AS Design Criteria and Industry Interface Subgroup.

Much work has been accomplished over the past years to assess and enhance non-nuclear combat survivability of U.S. aircraft. Part of that work includes a great deal of ballistic testing. To aid this test effort, an up-to-date survey was made and this guide prepared. This guide serves the JTCG/AS community as a reference to major ballistic test facilities in the U.S.

The authors wish to extend their appreciation for the assistance of Mr. A. F. Jones of the U.S. Army Materials and Mechanics Research Center, who prior to his retirement, was instrumental in providing assistance in coordinating site visits. The excellent cooperation of the facility representatives both during the site visits and in reviewing the draft facility descriptions provided valuable insight into the overall capability of each facility. The authors wish to express their appreciation of this cooperation and for the assistance of all who contributed to this guide.

NOTE

This technical report was prepared by the Vulnerability Assessment Subgroup of the Joint Technical Coordinating Group on Aircraft Survivability in the Joint Logistics Commanders' organization. Because the Services' aircraft survivability development programs are dynamic and changing, this report presents the best data available to the subgroup at this time. It has been coordinated and approved at the JTCG subgroup level. The purpose of the report is to exchange data on all aircraft survivability programs, thereby promoting interservice awareness of the DOD aircraft survivability program under the cognizance of the Joint Logistics Commanders. By careful analysis of the data in this report, personnel with expertise in the aircraft survivability area should be better able to determine technical voids and areas of potential duplication or proliferation.

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This JTCG/AS *Ballistic Test Facility Guide* presents the results of an aircraft survivability test-oriented survey of 18 government and industry test facilities. In addition to descriptions of actual ballistic test ranges, detailed information is presented on the types and sizes of projectiles which can be fired, instrumentation available, data processing capabilities, power/communication availability, safety and security arrangements, fabrication capability, logistics support availability, and facility access.

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BACKGROUND

JTCG/AS

JTCG/AS was formed by direction of the Joint Logistics Commanders (DARCOM/NMC/AFLC/AFSC) to determine and validate methodologies required to test, evaluate, and design survivability into aircraft and aircraft subsystems. The Design Criteria and Industry Interface Subgroup formed an ad hoc committee with the following objective: to review and evaluate military, government and commerical survivability/vulnerability ballistic test facilities, and establish a complete and ready reference directory of same.

RELATED RESEARCH

In March of 1973, Braddock, Dunn and McDonald, Inc.* (with the RMC Research Corporation as a subcontractor) entered into a contract with the U.S. Army OTEA (Operational Test and Evaluation Agency) to survey existing instrumented test sites which could be used for operational testing. Methodologies for collecting and presenting facilities information were developed which proved effective and economical. The resulting three volume *Operational Test Instrumentation Guide* was widely distributed throughout the test and evaluation community where it was universally well received. Following publication of this guide, a task was added to the contract which required a survey of all hardware simulators and computer simulations applicable to operational test and evaluation. During the conduct of this second task, the methodologies previously used where further refined and improved.

INTROUCTION

PURPOSE

To accomplish the ad hoc committee objective, the BDM Corporation and RMC Research Corporation were contracted to perform an up-to-date test facility survey. They used the same methodologies, modified as appropriate, that were previously successful. This new survey was to provide the ad hoc committee with documented capabilities of major ballistic test facilities within the U.S. This *Ballistic Test Facility Guide* presents the survey results and will serve as a convenient reference for members of the JTCG/AS and other interested agencies involved in planning aircraft survivability/vulnerability tests.

APPROACH

A three-phase approach was used in accomplishing this initial survey. This approach had been developed in conducting similar surveys and had proven to be effective, economical, and manageable.

*Now the BDM Corporation

Phase 1

The first phase consisted of reviewing available documentation concerning known ballistic test facilities, making contact with agencies and corporations having ballistic test facilities to get an idea of their capabilities, developing and coordinating a survey checklist and selecting from a large list of facilities those to be included in this survey. The facilities surveyed are listed in Table 1. (Figures and tables are at the end of each section.) Also included in this phase was a pilot survey of one facility in the Washington, D.C. area. This pilot survey served to validate the survey checklist and data collection procedures. The validated survey checklist was used as the outline for the annexes describing each facility's capabilities and is shown in Table 2.

Phase 2

The second phase consisted of visiting the selected test facilities and generating draft capabilities descriptions for each facility.

Phase 3

The third and final phase consisted of coordinating each annex with the facility concerned, modifying the drafts as necessary to incorporate comments from the facility, developing ready reference summaries of various aspects of the facility capabilities, coordinating a final draft with the designated representative of the JTCG/AS and publishing a final report.

Details of Approach

Each phase of the project was subdivided into subtasks to facilitate management of the overall project. These subtasks are discussed in the following paragraphs and graphically portrayed in Figure 1.

Survey Preparation - Phase 1.

DEVELOPMENT OF GOVERNMENT AND INDUSTRY FACILITY LIST - SUBTASK 1. The development of a master list of potential facilities to be surveyed in the initial information collection effort considered covering the total range of facilities from laboratory type ground test facilities through aircraft flight test centers such as the Naval Weapons Center, China Lake, CA. Only in this manner could the magnitude of the total capability assessment effort be understood.

REVIEW JTCG/AS TEST REQUIREMENTS - SUBTASK 2. Meetings with the JTCG/AS Central Office and subgroup representativies were held shortly after program approval to establish an understanding of the current ballistics test support requirements. These meetings established the facility requirements to support tests planned in the following areas:

1. Strengthening of the data base for vulnerability analysis and reduction
2. Evaluation of prototype aircraft hardware survivability
3. Validating design, analysis, and test methodologies for vulnerability reduction.

In addition, the current threat simulation requirements were reviewed.

FACILITY SELECTION AND TEST REQUIREMENTS REVIEW COORDINATION WITH JTCG/AS - SUBTASK 3. The results of the test facility survey master list development and the review of the latest aircraft survivability test requirements were coordinated with the JTCG/AS Steering Committee.

DEVELOPMENT OF A FACILITIES CHECKLIST - SUBTASK 4. A ballistic test facility survey checklist was developed by modifying the checklist developed for the OTEA instrumentation survey. The new checklist reflected the specific test requirements of the JTCG/AS as developed in Subtask 2.

TEST FACILITIES VISITATION LIST - SUBTASK 5. At this point, sufficient information was available to select the facilities to be initially surveyed from the master list. For this survey effort, the selection of facilties with the greatest potential for meeting the test needs of the JTCG/AS was indicated. This selection was a cooperative effort between BDM/RMC and JTCG/AS.

PILOT SURVEY - SUBTASK 6. As part of attaining the project goal of the producing survey reports that will be useful, a pilot survey was performed and a report prepared. The facility to be surveyed was the NOL (Naval Ordnance Laboratory). The survey will be conducted using the checklist developed in Subtask 4.

COORDINATION WITH JTCG/AS - SUBTASK 7. The coordination and approval of the pilot survey report organized according to the checklist format was the primary focus of this meeting. Completion of this subtask constituted completion of the first phase of the effort.

Facility Survey - Phase 2.

DRAFT PRELIMINARY FACILITY ANNEXES - SUBTASK 8. Prior to visiting each selected facility, the BDM/RMC teams, using the checklist outline, prepared a preliminary report on the facility. The data used were that which are obtainable from local sources (such as the Pentagon) and information on hand from the OTEA survey data base. Several benefits resulted from this technique. The BDM/RMC teams were familiar with the facility and its capabilities prior to their visit. They were also aware of the potential data gaps. This increased the effectiveness of the facility visit since most of the time was devoted to filling in these gaps, and adding any new information supplied by the facility personnel.

DRAFT OUTLINE OF SUMMARY VOLUME - SUBTASK 9. An outline of the basic contents of the Survey Summary report was developed based upon the approval of the pilot survey results and the approved list of facilities to be surveyed. This effort was accomplished at the same time the facility visits were being arranged and the capability background searches completed.

DRAFT SUMMARY DOCUMENT FOR FACILITY SURVEY GUIDANCE - SUBTASK 10. The draft summary document provided the BDM/RMC teams some perspective as to the relevance of each facility's capabilities. The document presented the capabilities and associated data of all the surveyed facilities in summary (generally matrix) form to permit rapid identification of candidate facilities to meet given test requirements. The information presented was derived from the detailed data in the facility descriptions.

With knowledge of the data classifications to be used in the summary, the capabilities of a facility could be determined according to the summary classifications during each facility visit. This procedure resulted both in improved quality of the summary and in reduction of the time required for its preparation.

FIELD SURVEYS - SUBTASK 11. Only after completion of all the above subtasks were the BDM/RMC survey teams thoroughly prepared to visit each facility. If properly prepared, a single facility visit should provide all the necessary facility capability updating information. One- or two-man teams visited each selected facility. Appointments with all critical facility personnel were arranged prior to the visit.

Completion of Facility Capability Documentation - Phase 3.

COORDINATION OF FINAL DRAFT FACILITY ANNEXES - SUBTASK 12. All facility capability information was coordinated with the facility visited. This coordination was accomplished by mailing a final draft of the annex to the primary point of contact at each facility and receiving his comments either by mail or telephone.

DRAFT SUMMARY COMPLETED - SUBTASK 13. A completely coordinated final draft of each annex was generated at this time and summary report information finalized. At this time, summarized facility capabilities revealed potential test support gaps.

COORDINATION WITH JTCG/AS - SUBTASK 14. Summary facility capabilities along with potential test support gaps was the focus of this meeting. Guidelines for preparing the final summary report were provided.

COMPLETED FACILITY SURVEY - SUBTASK 15. The final facility capability survey information is presented in one volume.

REPORT ORGANIZATION

Following this introduction, the capabilities of the 36 facilities surveyed are summarized in matrices covering firing capabilities, instrumentation, and data handling.

These summaries are designed to provide the user of this report with a ready reference system to help quickly identify which facility(s) have specifically desired capabilities.

Complete details on each facility are contained in annexes following the summary.

SUMMARY OF IMPORTANT DATA

FIRING CAPABILITIES

The firing capabilities of each facility are summarized in Tables 3 and 4.

In Table 3, the sizes or ranges of sizes of projectiles which can be fired at each facility are listed for each of five range bands, less than 35 feet, 35 to 50 feet, 50 to 100 feet, 100 to 400 feet, and greater than 400 feet. Also indicated is the capability of each facility to handle high explosive projectiles or charges and the limits of this capability. For example, the U.S. AMMRC (Army Materials and Mechanics Research Center), Annex C, can fire projectiles of from 0.2 to 12.7 mm at ranges of less than 35 feet; 0.1 to 37 mm at ranges of from 50 to 100 feet; and high explosives charges of up to 1/2 pound.

In Table 4, a slightly greater level of detail is presented. Here, the data are presented by range band for each individual subfacility. The length of each range is given together with the identification of the range, the size projectiles which can be fired and the types of projectiles which can be fired. For example, Range 3 at AMMRC is 20 feet long and can handle inert or incendiary projectiles of from 5.56 to 7.62 mm.

INSTRUMENTATION

The general instrumentation types available at each facility are summarized in Table 5. For each facility, an indication is provided as to whether there are indoor ranges, outdoor ranges, or both; what types of photographic capability is available; whether timing equipment is available and whether telemetry is available. For example, all ranges at AMMRC except the Detonics range are indoor facilities; x-ray, high speed motion picture and still photography are available; timing equipment is available and some form of telemetry is available.

DATA HANDLING/PROCESSING CAPABILITIES

A brief list of data handling/processing capabilities is in Table 6.

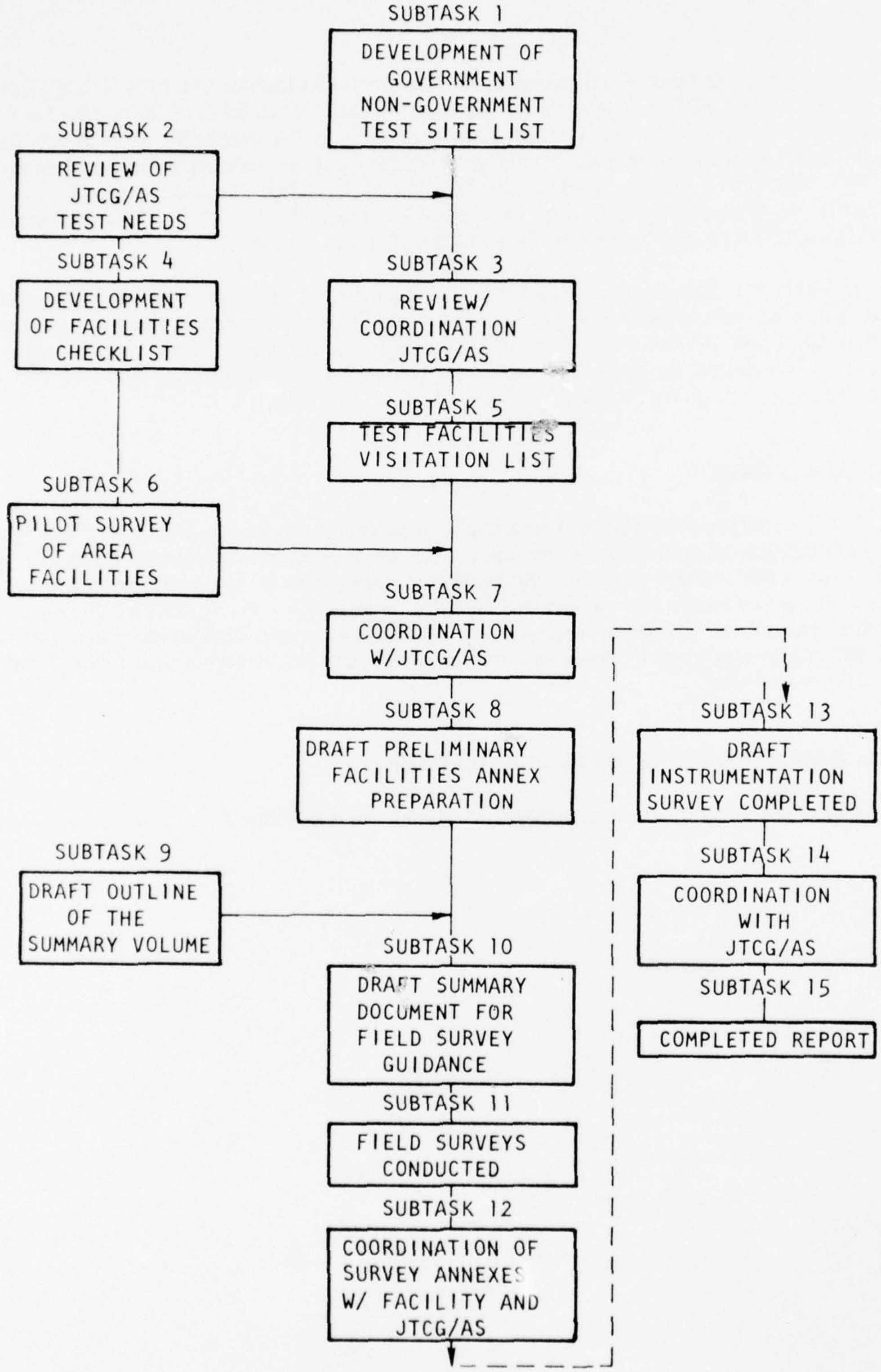

Figure 1. Flow Diagram of JTCG/AS Ballistic Test Facility Survey.

Table 1. Detailed Test Facility Description Annexes.

Annex	Facility	Abbreviation
A	Armament Development and Test Center, Elgin Air Force Base, FL	ADTC
B	Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, OH	AFFDL
C	Army Materials and Mechanics Research Center, Watertown, MA	AMMRC
D	Eustis Directorate, Fort Eustis, VA	AMRDL
E	Ballistic Research Laboratories, Aberdeen Proving Ground, MD	BRL
F	Naval Surface Weapons Center, White Oak Laboratory (Naval Ordnance Laboratory), Silver Spring, MD	NOL
G	Naval Surface Weapons Center, (Naval Weapons Laboratory), Dahlgren VA	NWL
H	Naval Weapons Center, China Lake, CA	NWC
I	Alcoa Technical Center, Alcoa Center, PA	Alcoa
J	Bell Helicopter Company, Fort Worth, TX	Bell
K	General Dynamics, Convair Division, San Diego, CA	Convair
L	FMC Corporation, Ordnance Engineering Division, San Juan Capistrano, CA	FMC
M	Philco-Ford Corporation, Capistrano Test Facility, San Juan Capistrano, CA	Ford
N	H. P. White Laboratory, Bel Air, MD	H. P. White
O	LTV Aerospace Corporation, Vought Systems Division, Dallas, TX	LTV
P	McDonnell Aircraft Company, St. Louis, MO	McDonnell
Q	United States Steel Research Laboratory, Monroeville, PA	U.S. Steel
R	Southwest Research Institute, San Antonio, TX	SwRI

Table 1. Detailed Test Facility Description Annexes (Contd.).

Annex	Facility	Abbreviation
S	AAI Corporation, Baltimore, MD	AAI
T	Biophysics Division, Biomedical Laboratory, Edgewood Arsenal, MD	Edgewood
U	Boeing Aerospace Company, Seattle, WA	Boeing
V	Boeing Company, Vertol Division, Philadelphia, PA	Vertol
W	Denver Research Institute, Denver, CO	DRI
X	Falcon Research and Development Company, Denver, CO	Falcon
Y	Firestone Coated Fabrics Company, Southgate, CA	Firestone
Z	General Electric Company, Armament Systems Department, Burlington, VT	GE
AA	Goodyear Aerospace Corporation, Engineered Fabrics Division, Akron, OH	Goodyear-Akron
BB	Goodyear Aerospace Corporation, Arizona Division, Litchfield Park, AZ	Goodyear-AZ
CC	Hughes Helicopters, Culver City, CA	Hughes
DD	New Mexico Institute of Mining and Technology, Socorro, NM	NMI
EE	Pacific Technical Corporation, Santa Barbara, CA	PATEC
FF	Picatinny Arsenal, Dover, NJ	Picatinny
GG	Rockwell International, Canoga Park, CA	Rockwell
HH	Sandia Laboratories, Albuquerque, NM	Sandia
II	Ultrasystems, Incorporated, Phoenix, AZ	Ultrasystems
JJ	Uniroyal, Incorporated, Uniroyal Plastic Products Division, Mishawaka, IN	Uniroyal

Table 2. Survey Checklist and Standard Annex Format.

A. INTRODUCTION

1. Overview
2. Generic Aircraft Systems (Subsystems) Tested
3. Survivability/Vulnerability Facilities Overview
4. Access
5. Maintenance/Fabrication Capability
6. Logistical Support Capability

B. INDOOR FACILITIES

1. Facility Name
   a. Dimensions
   b. Weapons/Projectiles Available
   c. Environment
   d. Live/Inert Fire
   e. Safety (and Security) Requirements
   f. Power Availability
   g. Observation/Communication
   h. Instrumentation
      1) In-Flight Ballistic
         a) Laser/Photography
         b) Timing
         c) Telemetry
         d) Other
      2) Terminal Ballistic
         a) Laser/Photography
         b) Timing
         c) Telemetry
         d) Other

C. OUTDOOR FACILITIES

1. Facility Name
   a. Dimensions
   b. Weapons/Projectiles Available
   c. Environment
   d. Live/Inert Fire
   e. Safety (and Security) Requirements

Table 2. Survey Checklist and Standard Annex Format (Contd.).

f. Power Availability

g. Observation/Communication

h. Instrumentation

1) In-Flight Ballistic
   a) Laser/Photography
   b) Timing
   c) Telemetry
   d) Other

2) Terminal Ballistic
   a) Laser/Photography
   b) Timing
   c) Telemetry
   d) Other

3) Environmental Simulation and Measurement

D. DATA HANDLING/PROCESSING

1. Data Storage and Retrieval

2. Quick-Look Capabilities

3. Processing

   a. System and Model

   b. Language(s)

   c. Input/Output Options

   d. Realtime/Interaction

4. Distribution

5. Displays

6. Other Items Unique to this Facility

Table 3. Summary of Firing Capabilities.

Annex	Facility	Range, ft					HE, lb
		35	35 to 50	50 to 100	100 to 400	400	
A	ADTC		Frag-12.7		Frag-40	4.3-75 mm	
B	AFFDL			Frag-30	Frag-37		
C	AMMRC	Frag-12.7	Frag-12.7	Frag-20			1/2
D	AMRDL				7.62-23 mm		
E	BRL	Frag-23	Frag-30	Frag-57	Frag-152	20-152 mm	8
F	NOL	Frag-12.7			6.35-50.8	-50.8 mm	1 1/2
G	NWL				5.56-127	-610 mm	5000
H	NWC			Frag-57		5.56-152 mm	2000
I	Alcoa		Frag-20				
J	Bell	Frag-23			Frag-23		
K	Convair	5.56-20 mm				23	
L	FMC	5.56-57			-90 mm	-81 mm	1000
M	Ford				-40 mm	-40	
N	H. P. White		Frag-30	Frag-40	5.56	5.56-57	
O	LTV				5.56-30		
P	McDonnell			Frag-20			
Q	U.S. Steel	Frag-20					
R	SwRI		Frag-7.62	5.56-57 mm		5.56-105	3
S	AAI	Frag-20		To 8-inch Frag7.62	5.56-203		
T	Edgewood	Frag-7.62		Frag-20	Frag-7.62	Frag-7.62	1/4
U	Boeing	Frag-40				Frag-40	200
V	Vertol			Frag-20			
W	DRI				Frag-30		200
X	Falcon		Frag-23				200
Y	Firestone			7.62-20 mm			
Z	GE				Frag-40	Frag-40	10
AA	Goodyear-Akron			Frag-23			
BB	Goodyear-AZ	Frag-14					
CC	Hughes		Frag-40	Frag-40			
DD	NMI				7.62-120 mm	Frag-155	1000
EE	PATEC		Frag-23			Frag-40	
FF	Picatinny				Frag-20	20-203	25
GG	Rockwell				5.56-30 mm		
HH	Sandia	Frag-20				-57	5
II	Ultrasystems				Frag-30		
JJ	Uniroyal			7.62-20 mm	7.62-20 mm		

Table 4. Summary of Firing Capabilities.

Range	Facility	Size	Projectile type
	35-foot range		
30'	AAI (30-Foot Indoor Range)	Frag-20	Incendiary: No HE
30'	Convair (Ballistic Test Facility)	Frag-20	Inert
30'	Edgewood (First Supplementary Range)	Frag-7.62	Inert
30'	Goodyear-AZ (Ballistic Test Facility)	Frag-14	Inert
30'	U.S. Steel (Ballistic Range)	Frag-20	Inert
25'	Bell (Ballistic Vulnerability Laboratory)	Frag-23	Inert
25'	FMC (Indoor Ballistics Range)	Frag-57	Incendiary: No HE
25'	NOL (Hypervelocity Impact Range 1)	Frag-12.7	Inert
20'	AMMRC (Range 3)	Frag-7.62	Incendiary: No HE
20'	AMMRC (Range 4)	Frag-7.62	Incendiary: No HE
20'	Bell (Bell Outdoor Range)	Frag-23	Inert
20'	BRL (Turbojet Engine Test Firing Range)	Frag-23 (1/2-lb HE)	Live
20'	Sandia (Guns Facility)	Frag-20	Inert
19'	BRL (Experimental Explosives Area)	Frag-17.5	Inert
16'	AMMRC (Detonics Facility)	(1/2-lb HE)	Live
12'	Edgewood (Second Supplementary Range)	Frag-5.56	Inert
10'	NOL (Explosion Dynamic Impact Facility)	2.54-20 mm	Live
9'	BRL (Range R-7A)	-2000 grain frag.	Live
Low ft	NOL (Air Launched Shock Test Facility)	52-127 mm	Live
Low ft	Boeing (Impact Mechanics Laboratory)	Frag-40	Incendiary: No HE
	35- to 50-foot range		
42'	Hughes (500-Inch Ranges)	Frag-40	Inert
40'	ADTC (Terminal Ballistic Instrumentation Site)	Frag-12.7	Inert
40'	Alcoa (Ballistic Firing Range)	Frag-20	Incendiary: No HE
40'	Falcon (Vertical Range)	Frag-23	Live
35'	AMMRC (Light Gas Launching Facility)	Frag-12.7	Inert
35'	BRL (Indoor Test Firing Range)	Frag-30	Inert
35'	PATEC (Indoor Range)	Frag-23	Incendiary: No HE
35'	SwRI (Impulsive Loading Laboratory)	Frag-7.62	Live
35'	H. P. White (35-Foot Ballistic Range)	5.56-30 mm	Inert
	50- to 100-foot range		
90'	SwRI (Terminal Ballistic Laboratory)	5.56-57 mm	Live
83'	Hughes (1000-Inch Indoor Range)	Frag-40	Inert
83'	Hughes (1000-Inch Indoor/Outdoor Ranges)	Frag-40	Inert
83'	McDonnell (Bldg. 13C Gunfire Test Facility)	Frag-20	Live
80'	NWC (Aircraft Survivability Range)	Frag-57	Live
80'	Vertol (Ballistic Test Facility)	Frag-20	Incendiary: No HE
75'	Firestone (Ballistic Test Range)	7.62-20 mm	Incendiary: No HE
75'	Goodyear-Akron (Gunfire Range)	Frag-23	Live
75'	McDonnell (Bldg. 62 Gunfire Facility)	12.7-14.5 mm	Incendiary: No HE
75'	Uniroyal (Non-Incendiary Range)	7.62-20 mm	Inert

Table 4. Summary of Firing Capabilities (Contd.).

Range	Facility	Size	Projectile type
	50- to 100-foot range (contd.)		
75'	AAI (70-Foot Indoor Range)	Frag-30	Incendiary: No HE
65'	BRL (Penetration Facility)	Frag-30	Inert
60'	AFFDL (Range 3)	Frag-37	Live
60'	McDonnell (Bldg. 13C Gunfire Test Facility)	Frag-20	Live
59'	Edgewood (Main Range)	Frag-20	Incendiary: No HE
55'	BRL (Blast Sphere Facility)	7-57 (8-lb HE)	Live
50'	AMMRC (Range 1)	5.56-20	Incendiary: No HE
50'	AMMRC (Range 2)	5.56-20	Incendiary: No HE
50'	BRL (Helicopter Main Blade Ballistic Test Facility)	Frag-23	Live
50'	H. P. White (All-Angle Firing Pit)	5.56-40	Live
	100- to 400-foot range		
350'	Rockwell (Happy Valley Gunfire Range-Upper)	Frag-30	Live
328'	Edgewood (100-Meter Range)	Frag-7.62	Incendiary: No HE
300'	AAI (100-Yard Indoor Range)	Frag-20	Incendiary: No HE
300'	ADTC (Gun System Test Facility)	Frag-40	Inert
300'	AFFDL (Range 2)	Frag-37	Live
300'	Bell (Remote Test Facility)	Frag-23	Live
300'	FMC (Site 1 - Dolomite Quarry)	-90 (1000-lb HE)	Live
300'	NOL (Pressurized Ballistic Range)	Frag-50.8	Small Point Detonating
300'	Rockwell (Happy Valley Gunfire Range-Lower)	Frag-30	Live
300'	Ultrasystems (Ballistic Test Range)	Frag-30	Live
300'	H. P. White (100-Yard Indoor Ballistics Range)	Frag-30	Inert
275'	AFFDL (Range 1)	Frag-23	Incendiary: No HE
260'	GE (Munitions Test Area)	Frag-40	Live
250'	Uniroyal (Incendiary Range)	7.62-20	Incendiary: No HE
250'	ADTC (BARS Facility)	Frag-40	Inert
230'	Ford (Gun Range 1)	Frag-30	Live
200'	DRI (Denver Federal Center Facility)	Frag-30	Inert
200'	NMI (Cliff Site)	7.62-30	Live
200'	NMI (Hill Top Site)	7.62-120	Live
200'	NMI (Structural Testing Complex)	7.62-30	Live
200'	NMI (Ballistic Effects Dynamic Data Device)	7.62-30	Live
160'	NWL (Machine Gun Range)	7.62-127	Live
160'	Picatinny (Range 620)	Frag-20	Inert
150'	AMRDL (BTRACS)	7.62-23	Live
150'	LTV (Gunfire Test Facility)	Frag-30	Live
135'	ADTC (Terminal Ballistics Facility)	Frag-30	Inert
110'	Rockwell (Tunnel Gunfire Range)	5.56-30	Live
100'	AAI (Quarry Ranges)	-203	Live
100'	ADTC (Terminal Ballistics Facility)	Frag-30	Inert
100'	AMRDL (Ballistics Range)	7.62-30	Live
100'	BRL (Utility Outdoor Range)	Frag-57	Live
100'	Ford (Special Test Site)	Frag-40	Live

Table 4. Summary of Firing Capabilities (Contd.).

Range	Facility	Size	Projectile type
	400-foot range		
37 mi	NWC (Missile Firing Ranges)	-Large caliber	Live
37 mi	NWC (Missile Ballistic Ranges)	-Large caliber	Inert
25 mi	NWL (Main Range)	-406	Live
25 mi	NWL (Anti-Aircraft Fuse Range)	-203	Live
25 mi	NWL (Missile Range)	(100-lb HE)	Live
6567'	PATEC (Camp Roberts Facility)	Frag-40	Live
4925'	NMI (Valley Site)	Frag-155	Live
4600'	GE (Vehicle and Helicopter Range)	Frag-40 mm	Inert
3281'	Ford (1000-Meter Range)	-40	Live
3281'	NMI (West Valley Test Facility)	Frag-155	Live
3281'	NWC (Small Caliber Gun Range)	-20 mm	Live
3281'	NWC (Gun Target Range)	-Large caliber	Live
3000'	FMC (Site 2, Hollister Facility)	-81 (150-lb HE)	Live
2200'	ADTC (Terminal Effects Experimentation Facility)	-75	Live
2000'	ADTC (Gunnery Ballistics Facility)	-30	Live
2000'	SwRI (Camp Bullis Facility)	-Artillery	Live
1642'	Edgewood (500-Meter Range)	Frag-7.62	Incendiary: No HE
1500'	SwRI (Terminal Ballistics Laboratory)	5.56-57	Live
1313'	H. P. White (400-Meter Ballistic Range)	5.56-57	Live
1000'	NOL (1000-Foot Hyperballistic Range)	-50.8	Small Point Detonating
1000'	NWL (Terminal Range)	-610	Live
821'	Ford (Gun Range 1)	Frag-30	Live
821'	Ford (Gun Range 2)	Frag-30	Live
741,	Ford (Turret Range)	-40	Live
700'	ADTC (Aeroballistic Research Facility)	4.3-40	Inert
675'	BRL (Large Caliber Penetration Range)	20-152	Live
600'	GE (Main Range)	Frag-40	Inert
400'	Picatinny (Range 636)	20-203	Inert
400'	Picatinny (Range 1242)	20-203	Live
2400 acres	Convair (Sycamore Site)	-23 mm	Live
2200 acres	Boeing (Tulalip Test Site)	Frag-40 (10-lb HE)	Live

Table 5. Summary of Instrumentation.

Facility	Photo	Timing	Telemetry
ADTC			
(Indoor)	XHS	Yes	No
(Outdoor)	XHS	Yes	Yes
AFFDL			
(Indoor)	XHS	Yes	Yes
(Outdoor)	H	Yes	Yes
AMMRC			
(All indoor except detonics)	XHS	Yes	Yes
(Detonics)	XHS	No	Yes
AMRDL			
(Outdoor)	HSV	Yes	Yes
BRL			
(Indoor)	XHS	Yes	Yes
(Outdoor)	HS	Yes	Yes
NOL			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XH	Yes	Yes
NWL			
(Indoor)	HS	Yes	Yes
(Outdoor)	HS	Yes	Yes
NWC			
(Outdoor)	HS	Yes	Yes
Alcoa			
(Indoor)	S	Yes	No
Bell			
(Indoor)	XH	Yes	Yes
(Outdoor)	H	No	Yes
Convair			
(Indoor)	H	Yes	Yes
(Outdoor)			
FMC			
(Indoor)	XH	No	Yes
(Outdoor)	HS	Yes	Yes
Ford			
(Indoor)	XH	Yes	Yes
(Outdoor)			
H. P. White			
(Indoor)	XHS	Yes	Yes
(Outdoor)	HS	Yes	Yes
LTV			
(Outdoor)	H	Yes	No

Table 5. Summary of Instrumentation (Contd.).

Facility	Photo	Timing	Telemetry
McDonnell			
(Indoor)	H	Yes	Yes
U.S. Steel			
(Indoor)	HS	Yes	No
SwRI			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes
AAI			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes
Edgewood			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes
Boeing			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes
Vertol			
(Indoor)	HS	Yes	Yes
DRI			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes
Falcon			
(Outdoor)	HS	Yes	Yes
Firestone			
(Outdoor)	HS	Yes	Yes
GE			
(Outdoor)	XHS	Yes	Yes
Goodyear-Akron			
(Outdoor)	HS	Yes	Yes
Goodyear-AZ			
(Indoor)	HS	Yes	No
Hughes			
(Indoor)	HS	Yes	Yes
(Outdoor)	HS	Yes	Yes
NMI			
(Outdoor)	XHS	Yes	Yes
PATEC			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes
Picatinny			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHS	Yes	Yes

Table 5. Summary of Instrumentation (Contd.).

Facility	Photo	Timing	Telemetry
Rockwell			
(Indoor)	XHS	Yes	Yes
(Outdoor)	XHSV	Yes	Yes
Sandia			
(Indoor)	HS	Yes	Yes
(Outdoor)	HS	Yes	Yes
Ultrasystems			
(Outdoor)	HS	Yes	Yes
Uniroyal			
(Outdoor)	HS	Yes	Yes

LEGEND: X = x-ray; H = high-speed photo; S = still; V = video tape.

Table 6. Summary of Data Handling/Processing Capabilities.

Facility	Storage/Ret	Quick-Look	System	Language	In/Out	Realtime	Distribution	Unique
ADTC	Card Tape	Photo 7 min to 1 day	2-CDC 6600 1-IBM 360/65 1-B 3500	Compass Fortran Cobol Sort/Merg Mars VI Mimic	Card Tape Line	Yes	Realtime to 1 day	
AFFDL		Oscillograph Counters Temp records CCTV	HP2100S CDC 6600			CCTV	24 to 48 hrs	
AMMRC	Card Tape	Photo 30 min	Univac 1106	Fortran IV & V	Card Tape Line Print	Yes HP9810A	1 day	
AMRDL	Cards Tape	Oscillograph Videotape	IBM 360/65 CDC 6600 Univac 1108	Fortran IV	Printout Tape	None	24 hrs	
BRL	7-9 track Cards	Photo 30 min	BRLESC 1 & 11 IBM 1401 EAL 690	Fortran Forast Omnitab	Card Tape Printout	None	Photo 30 min to 1 week	
NOL	Card Disk Tape	Photo 10 min	CDC 6500	Compass Fortran Snobol Simscript Cobol Basic	Card Tape Printout	None	1 day	
NWL	Photo Cards Tape Disk	Minutes- Photo	CDC 6700 3X CPU CDC 14173, 1774, 6713	Compass Fortran Snobol Simscript Cobol Basic	Card Print Tape Plotter	None	24 hrs	

Table 6. Summary of Data Handling/Processing Capabilities (Contd.).

Facility	Storage/Ret	Quick-Look	System	Language	In/Out	Realtime	Distribution	Unique
NWC	Drum Disk Tape	Teleprinter CRT	Univac 1110	Assembler 1100 Fortran V CFOR 1100 DOD Cobol ASC1/ASC11 Cobol PDP UBasic RFOR	Drum Disk Tape	None	24 hrs	
Alcoa	Tape Disk Cards	None	DEC System 10 IBM 370/158	Fortran Cobol Basic	Data 100	Yes Comp	All info for 60 firings in 1 day	
Bell	Film Tape Oscillograph	Oscillograph Oscillograph Counters	TI960A		Tape	None		
Convair			CYBER72					
FMC			IBM 2922 IBM 370/155					
Ford	Tape							
H. P. White	Tape Polaroid	None	None	None	None	None	Photo 30 min	Motion analysis
LTV	Film Tape	Oscillograph	Sigma 7			None	24 hrs	
McDonnell			CDAS			Yes Comp		

Table 6. Summary of Data Handling/Processing Capabilities (Contd.).

Facility	Storage/Ret	Quick-Look	System	Language	In/Out	Realtime	Distribution	Unique
U.S. Steel	Cards Data Sheets	None	CDC 6500		Card	None	50 firings to 1 day	
SwRI	Card Tape Disk	1 min/ 1 day	Data Gen Super Nova	Fortran Compass Cobol Basic	Card Tape Line Print	HP2005C	Data dependent	
AAI	Card Tape Disk	30 min	Gen Auto 18/30 IBM 370/165 Interdata 70	Fortran Cobol	Standard Calcomp 738	Yes	Immed to overnight	Vanguard motion analyzer
Edgewood	Papertape Card Tape Disk	15 min	Univac 1108	Fortran Cobol Basic PL/1	Standard Calcomp	Yes	2 min to overnight	
Boeing	Film Trace Tape	24 hrs	Available if required					
Vertol	Card Tape Disk Plots	2 hrs	IBM 360/65 IBM 370/158	ARC Common	Standard Calcomp	Yes	Immed	
DRI	Card Tape Disk	Immediate	Burroughs B6700	Fortran Basic Algol Cobol PL/1	Standard	Yes	Immed to overnight	
Falcon	Card Disk Tape	Immediate	Gen Auto SPP-16/85	Fortran Basic	Standard Calcomp 936		Immed	

Table 6. Summary of Data Handling/Processing Capabilities (Contd.).

Facility	Storage/Ret	Quick-Look	System	Language	In/Out	Realtime	Distribution	Unique
Firestone	Photo Trace	Few hrs						
GE	Tape Disk Card	Immediate	DEC 140 Honeywell 6000 Honeywell G400 EAI 680	All Common	Standard Calcomp X-Y plotter CRT	Yes	Immed	Interactive graphics terminal
Goodyear- Akron	Disk Tape Card	Oscillograph- immediate B&W 1 to 2 days	IBM 370 IBM 1130 Xerox Sigma 9	Fortran Cobol PL/1	Standard CRT Calcomp	Yes	5 to 10 min	
Goodyear- AZ	Film Hard- copy	Velocity- immediate B&W within 5 days						
Hughes	Tape Card	Short time after test	Several available			Yes		
NMI	Photo Tape Disk Film	1 hr for B&W 24 hrs for color	IBM 360/40	Any Standard	Standard Calcomp		Very short	
PATEC			Wang 360 Calculator					
Picatinny	Film Card Tape Disk		CDC 6500 EAI 8800	Any Standard	Standard	Yes	Immed	Interactive graphics terminal
Rockwell	Film Tape	Immediate video replay	IBM 370/165 IBM 360/135	Fortran Cobol PL/1	Standard	Yes		

Table 6. Summary of Data Handling/Processing Capabilities (Contd.).

Facility	Storage/Ret	Quick-Look	System	Language	In/Out	Realtime	Distribution	Unique
Sandia	Film Trace Tape Plots	Same day	Available				Same day	Semi-automatic film analyzer
Ultrasystems	Film Trace Hardcopy	Immediate video replay	Univac 1108 HP PH2100A		Standard	Yes	Immed	Vanguard motion analyzer
Uniroyal	Film Hardcopy		IBM 370/125	Fortran Cobol RPG BAC	Standard	No	Immed	

ANNEX A - INTRODUCTION

OVERVIEW

The ADTC (Armament Development and Test Center), Eglin Air Force Base, FL, is located close to Fort Walton Beach in northwest Florida on Florida State Road 85. The primary mission of the ADTC including AFAL (Air Force Armament Laboratory) is the development, testing, and initial procurement of guided and unguided, nonnuclear munitions. Testing primarily involves Air Force systems, with limited joint service and other service system testing. Such testing includes: air-to-ground munitions, aircraft gun systems and munitions, air-to-air missiles, electronic warfare systems, mines, fuzes, and aerial targets. The land test complex of ranges and facilities covers more than 750 square miles. To accomplish this testing, ADTC has a variety of capabilities including a climatic hangar/laboratory, indoor and outdoor ballistic ranges, explosive test facilities, ordnance test ranges, fuze test facility and many other support capabilities such as the Computer Sciences Laboratory.

The majority of the ballistics and ordnance test range efforts are under the 3246th Test Wing. The primary point of contact for use of these facilities is LCOL Thomas Fields (TGPM), telephone 904-882-4259.

The indoor gun tunnels and BARS (Ballistic/Aerodynamic Research Systems) facility are under the cognizance of the AFAL. Primary point of contact concerning testing in these facilities is COL James Jones (DLX), telephone 904-882-4444.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The AFAL performs vulnerability testing of complete aircraft systems and subsystems such as wings, fuselage, propulsion systems, and fuel cells. Representative aircraft used as targets are the A-4, F-84F, and F-102.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There are four indoor and four outdoor ballistic test facilities located at ADTC. Two of the indoor and one of the outdoor facilities are devoted to in-flight ballistics testing with the remainder being primarily used for terminal ballistics information. In addition there are several HE (high explosive) test areas for static testing of warheads to obtain fragment pattern, velocity, and mass distribution information. These facilities have instrumented ballistic ranges from a few feet to 2000 feet and vary from the full spectrum of altitude/temperature environmental simulation to ambient atmospheric conditions. The indoor and two of the outdoor ranges are restricted to inert projectiles. The other outdoor ranges can accommodate explosive detonating rounds up to 105-mm in size.

ACCESS

The ADTC has excellent access by road: Interstate 10 and U.S. Highway 88 for east-west movement and Florida State Road 85 for north-south. Eglin Air Force Base provides excellent air facilities for Military and Southern Airways, commercial. Rail access currently exists via a government-owned spur line connecting with the Louisville and Nashville Railroad. Water excess by flat bottom barge is possible, but no deep water port is available.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capabilities at ADTC are superior to those found at most test locations, ranging from laboratory precision modeling to major machine, sheet metal, and fiberglass shops. In addition, a capability exists for the design and fabrication of special instrumentation for any testing conducted at ADTC.

LOGISTICAL SUPPORT CAPABILITY

Normal logistic support capability exists associated with a military installation of this size. Numerous ordnance storage bunkers exist in the central ordnance storage area of Eglin Air Force Base. Storage time allowed for test items is commensurate with the length of the test series. Small secure storage areas are associated with some of the test facilities with quantities and duration of storage severely limited.

MILITARY UNITS NEARBY

Tenant military organizations on the Eglin Air Force Base complex are:

1. Army

   Army Ranger School

2. Military Airlift Command

   39th Aerospace Rescue and Recovery Wing

   Detachment 10, 6th Weather Wing

3. Tactical Air Command

   TAWC (Tactical Air Warfare Center)

   Special Operations Wing

   33rd Tactical Fighter Wing

   557th Civil Engineering Squadron

   919th Tactical Airlift Group, Reserve

   AGOS (Air-Ground Operations School)

4. Aerospace Defense Command
   20th Surveillance Squadron
5. Air Force Communications Service
   1972nd Communications Squadron

GOVERNMENT INSTALLATIONS NEARBY

1. Pensacola Naval Air Station (50 miles)
2. Tyndall Air Force Base (65 miles)
3. Naval Coastal Systems Laboratory (60 miles)
4. Fort Rucker, AL (100 miles)

INDOOR FACILITIES

AEROBALLISTIC RESEARCH FACILITY (Range A-22)

Dimensions

The Aeroballistics Research Facility is a 700-foot-long exterior ballistics tunnel of which 655 feet can be instrumented. The first 200 feet of the tunnel has a cross-section of 12 ft^2, while the final 500 feet is 16 ft^2. The "window" or cross-section covered by the instrumentation is 7 1/2 feet in diameter.

Weapons/Projectiles Available

At present, only single-shot firings are slated for the facility using Mann barrel firing fixtures of varied sizes accommodating from .17 caliber to 40-mm gun projectiles.

Environment

There is no capability for environmental control. All firings conducted at ambient atmospheric conditions.

Live/Inert Fire

Only inert projectiles will be fired.

Safety (and Security) Requirements

Classified materials and equipment can be accommodated. All safety-related functions are controlled by central control. No personnel are allowed to observe outside of the control room during operations.

Power Availability

Because of indoor and highly controlled nature of this facility, power availability for weapon usage ranges from 110, 220, and 440 VAC to 28 VDC.

Observation/Communication

Intercom communications and control room observations are the only capabilities in this area. No remote television capability is deemed necessary.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A total of 131 data recording stations are spaced at 5-foot intervals along the length of the tunnel. Fifty sets of instrumentation—each set composed of horizontally and vertically directed cameras with built-in illuminated fiducial markers and numerical displays of calibration data, mission numbers and timing information, spark illuminators and IR (infrared) "trigger" screens—can be deployed at these stations to obtain data for the determination of cyclic angular motion and drag coefficients of the projectiles. Expected accuracies obtainable are 0.01 inch in position and 1/20th degree in yaw and pitch.

A cyclic chronograph can be used at each station to measure velocities up to 2000 ft/sec using a 6000 revolution/min rotational speed.

TIMING. Timing is accomplished by electronic counters in conjunction with the light detectors and chronographs. Numerical time displays are recorded on each film plate and displayed in realtime in the central control room.

TELEMETRY. None is available other than hardwired timing information.

Terminal Ballistic Instrumentation

None is currently available.

Environmental Simulation and Measurement

No environmental simulation control is available.

Planned Expansion/Modification

Installation of flash x-ray equipment in blast chamber between gun muzzle and instrumented tunnel to obtain intermediate ballistics while the projectile is still under the influence of muzzle blast is planned by 1 July 1975, when tunnel reaches full operational capability.

TERMINAL BALLISTICS FACILITY (Range A-22)

Dimensions

Two indoor gun tunnels are in operation for obtaining terminal ballistics information. Tunnel 9 is 100 feet long by 8 feet high by 10 feet wide. Tunnel 10 is 135 feet long by 7 feet high by 10 feet wide.

Weapons/Projectiles Available

Mann barrels are available in sizes from 5.56 to 30 mm for projecting fragments and projectiles at velocities up to 6000 ft/sec.

Environment

There is no environmental control in these tunnels.

Live/Inert Fire

Only inert projectiles are fired.

Safety (and Security) Requirements

Safety is controlled from the control/instrumentation room. Secure storage is available in an adjacent building.

Power Availability

220 volt 3-phase power is available in the instrumentation room; only standard 110-volt commercial power, available in the tunnels.

Observation/Communication

No realtime observation is allowed. Tunnels are evacuated for firings.

In-Flight Ballistic Instrumentation

Only terminal ballistic instrumentation is available other than light screens for velocity determination prior to target impact.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Terminal effects information is obtained at and behind the target material with one 150 kV mulitple flash cine x-ray system and one 300 kV multiple tube system (three orthogonal pairs). Six-speed graphic cameras coupled with a 16-pulse strobe generator can also be accommodated in the terminal area. Quick-look processing of x-ray film is accomplished at the facility within 7 minutes of firing. Accuracies obtainable are ±0.1% in velocity and ±0.01% in masses and the projectiles and/or fragments.

TIMING. Timing is provided by electronic counters to ± μsec accuracy.

TELEMETRY. Only hardwired gun function and target impact events are monitored.

Environmental Simulation and Measurement

No environmental control capability exists in these tunnels.

Planned Expansion/Modification

No modification are planned at this time.

TERMINAL BALLISTICS INSTRUMENTATION SITE (Range A-22/Bldg. 415)

Dimensions

The Terminal Ballistics Instrumentation site contains a 40-foot-long, 2-stage, powder/helium hypervelocity projector with a 36-inch-diameter target chamber.

Weapons/Projectiles Available

The hypervelocity projector can accommodate fragment shapes up to 1/2 inch in diameter. Normal operating velocities are in the 8000 to 10,000 ft/sec range to simulate warhead fragmentation effects.

Environment

The atmosphere in the target chamber can be varied from 10 microns to 1 atmosphere.

Live/Inert Fire

Only inert projectiles may be fired.

Safety (and Security) Requirements

All personnel must be in the control room during firing. Secure storage available at the facility.

Power Availability

110, 220, and 440 VAC are available at this facility.

Observation/Communication

No realtime observation is allowed.

In-Flight Ballistic Instrumentation

Only terminal ballistic information is available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Impact and spallation data can be obtained by flash x-ray (one orthogonal view) and Hycam cameras capable of 10,000 frames/sec.

TIMING. Electronic counters provide timing for velocity data.

Environmental Simulation and Measurement

The pressure in the target chamber can be varied from 10 microns to 1 atmosphere.

Planned Expansion/Modification

No modifications are planned at this time.

GUN SYSTEM TEST FACILITY (Range A-22)

Dimensions

The Gun System Test Facility consists of seven prewired enclosed firing bays and two central instrumentation/control rooms. The firing range is 300 feet in length from the gun bay door to the target butts. The gun bays are approximately 20 ft^2 by 8 feet high.

Weapons/Projectiles Available

User normally provides gun systems up to 40-mm in size.

Environment

All firings are conducted at ambient sea level pressured conditions.

Live/Inert Fire

Only inert firing can be accommodated currently.

Safety (and Security) Requirements

Classified materials and equipment can be accommodated. A tower operator coordinates all safety-related functions with the operators. Range is cleared during firings.

Power Availability

ELECTRICAL. Commercial power plus a 28-VDC rectifier and two 120/208 volt, 400-Hz, 3-phase, 0.8 pF, MD-4 power supplies. System provides 208 volt, 4-wire, y-connected, 175-ampere, 3-phase power or 3-phase, 3-wire, delta-connected, 303-ampere, 120-volt, and 1-phase, delta-connected, 120-volt, 3-wire, 520-ampere power.

HYDRAULIC. A central, fixed unit provides hydraulic power for gun system operations at 20 to 100 gal/min at up to 5000 psi. External source will provide 10 to 60 gal/min at up to 3000 psi.

Observation/Communication

A central CCTV (closed circuit television) system is installed with remote controlled cameras in each bay and monitors in the firing consoles and central television room. The central television room can record and reproduce video tapes of any bay operation.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. CCTV with a voice track is standard for firing operation in this facility. Hycam high-speed (10,000 frames/sec) camera can be made available, if required.

TIMING. Computer chronograph provides direct readout of individual velocities, average velocity of a burst, and rate of fire over a selected portion of a burst.

HARDWIRED:

1. Muzzle velocity - 0 to 5000 ft/sec ±25 ft/sec, 5.56- to 40-mm projectiles, burst velocities at rates of fire from 0 to 10,000 shots/min. ECI 6100 Lumiline velocity screens coupled with ECI S-144 cycle chronograph.

2. Rate of fire - 0 to 10,000 shots/min ±5% instantaneous and ±1% for average rates over 10 or more rounds. Electro Projects 3040A or 3015 magnetic pickup.

3. Relative action time - 0 to 30 msec ±0.5 msec 0 to 10,000 shots/min. Susquehanna ST-2 piezoelectric blast gage.

4. Gun hydraulic power - Flow rates ±1 gal/min Ramapo Mark IV strain gage flow meters. Pressure ±20 psi for line or differential pressures. BLH Model HHD strain gage differential pressure transducers.

5. Round-by-round dispersion - Accurate to one-half diameter of projectile at rates of fire in excess of 8000 shots/min. Target sizes 2 by 2 feet to 8 by 8 feet at 1000 to 3000 inches downrange. HRB Singer acoustic sensors and HRB Singer automatic scoring system.

OTHER. Each instrumentation room contains a 24-channel recording light beam oscillograph, a 14-channel analog FM tape recorder and a 10-channel constant bandwidth voltage-controlled oscillator system. A hardline telemetry link to the Computer Sciences Laboratory provides the capability for limited realtime or near realtime data processing using a PDP-15 computer and return display via teletype. Extensive analysis is performed by the CDC-6600 computer using the MARS VI program.

Terminal Ballistic Instrumentation

None currently available.

Planned Expansion/Modification

None are planned at this time.

OUTDOOR FACILITIES

TERMINAL EFFECTS EXPERIMENTATION FACILITY (Range 64A)

Dimensions

The Terminal Effects Experimentation Facility (T-facility) is a multipurpose, irregularly shaped, outdoor range with a maximum firing range of 2200 feet. Current firings are primarily conducted at ranges to 300 feet.

Weapons/Projectiles Available

Shapes representing fragments or projectiles up to 75-mm with HE warheads can be fired at this range. Most firings are conducted with Mann barrels. Targets range from characteristic plates to "G" loaded complete aircraft systems (A-4, F-84F, F-102).

Environment

Tests are run at ambient atmospheric conditions only.

Live/Inert Fire

HE warhead projectiles up to 75-mm size can be accommodated. All firings conducted into butts to contain fragments.

Safety (and Security) Requirements

The range is cleared before test firings. Safety is controlled from the blockhouse/instrumentation building via periscope, CCTV and loudspeaker system.

Power Availability

Blockhouse/instrumentation building has up to 440 volts power available. 220 volts, 3-phase power is available up to 800 feet from blockhouse.

Observation/Communication

Tests can be observed in realtime through CCTV, and directly by standard blockhouse periscope type arrangement.

In-Flight Ballistic Instrumentation

Projectile/fragment velocities obtained through light screens, or conducting foil screens with chronograph.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Most instrumentation is portable and available as required, including 150 kV flash x-ray (6 channel/3 orthogonal view) and Cordin Model 330 simultaneous streak and frame recording system with a capability of 2.6 by 10^6 pictures/sec. A Cordin Model 607 high intensity square wave light source is employed with the Model 330 camera.

TIMING. Electronic counters and IRIG timing are available for camera light screen actuated x-ray stations. In addition, an event sequencer is available in the blockhouse, with 30 programmable channels capable of 1 μsec programming accuracy.

HARDWIRED. Blockhouse hardwired instrumentation includes:

1. Bell and Howell VR3700B, 14-channel magnetic tape recorder, 80 kHz response

2. Computing chronograph, 12 velocity channels, digitized velocity output, time logged

3. 20-channel temperature recording, ambient to 2000°F, up to 100 samples/sec scan rate.

Planned Expansion/Modification

A new terminal ballistics facility containing two gun bays and three separate target ranges of 100, 300, and 1000 feet, respectively, each with surveyed instrumentation pads, was completed in 1976. Firing of HE projectiles up to 105-mm in size will be accommodated.

GUNNERY BALLISTICS FACILITY (Range C-74L)

Dimensions

The Gunnery Ballistics Facility is an outdoor facility for obtaining exterior ballistic information on HE projectiles. Firing is conducted over a maximum range of 2000 feet.

Weapons/Projectiles Available

Mann barrels are available up to 30-mm in size. User provided, full-up weapon systems can be tested. Two gun bays are available.

Environment

Tests are run at ambient atmospheric conditions.

Live/Inert Fire

Either live or inert projectiles may be fired up to 30-mm in diameter.

Safety (and Security) Requirements

The range is cleared before test firings. No secure storage is available.

Power Availability

60-cycle, 3-phase, 4-wire, 440 volt and 200 amperes, 3 to 50 kVA transformers; 60-cycle, 3-phase, 4-wire, 200 volts, 200 amperes, 3 to 15-kVA transformers.

Observation/Communication

Observation of actual firings can be accomplished through CCTV.

In-Flight Ballistic Instrumentation

Currently being installed is an equivalent set of instrumentation to that in use at the Gun System Test Facility, Range A-22.

LASER/PHOTOGRAPHY. Equipment is mostly portable and brought in as required. Includes: flash x-ray, Lumiline velocity screens, high-speed cameras, and yaw cards.

TIMING. IRIG timing and electronic counters.

HARDWIRED. Lumiline velocity screens and gun function information are the normal hardwired instrumentation.

Terminal Ballistic Instrumentation

Equipment is mostly portable and brought in as required, including flash x-ray, photographic and pressure instrumentation. A portable rapid-response, pressure sensing system is used to confirm fuze arming of HE projectiles. The capability is present of separating explosions occurring at 4000 rounds/min rate.

BARS FACILITY (Range A-22)

Dimensions

The BARS range associated with gun projectile ballistics is 250 feet long. It is instrumented over the first 200 feet.

Weapons/Projectiles Available

Mann barrels up to 40-mm in size are available for use at this range.

Environment

Outdoor range. Firings are conducted at ambient atmospheric conditions only.

Live/Inert Fire

Only inert projectiles may be launched at this range.

Safety (and Security) Requirements

The range is cleared for firing. Projectiles must be confined to 30 degrees including cone angle from gun muzzle.

Power Availability

Commercial power is available for operation of cameras and instrumentation over the 200-foot instrumented length.

Observation/Communication

Observation and communication are limited due to safety and facility configurations.

In-Flight Ballistic Instrumentation

Yaw card range is instrumented over a 200-foot length with 6 to 10 stations. Projectile attitude at each card penetration is reduced manually.

LASER/PHOTOGRAPHY. Laser beams and circuit paper provide stop-start signals for chronograph recording of velocities. High-speed photography (1000 to 10,000 frames/sec) provides source of additional projectile convolutions in flight.

TIMING. Timing is 1 μsec accuracy achieved with electronic timers for event sequencing and velocity measurement.

HARDWIRED. Gun function and paperbreak velocity information is usually the only hardwired instrumentation.

Planned Expansion/Modification

No modifications are planned at this time.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The majority of data collected at these facilities are in the form of photographs (optical, x-ray, or shadowgraph). Some data are manually read from the photographs and keypunched on computer cards. The remainder can be machine read and recorded. Data can be stored on disc or magnetic tape.

QUICK-LOOK CAPABILITIES

Photographs are available from 7 minutes (test site processing) to 1 day after the test. Data reduction from photographs requires at least 1 day after receipt of the photographs–depending upon the length of the test, instrumentation configuration, and amount of data to be extracted from the photographs.

PROCESSING

System and Model

The ADTC Computer Sciences Laboratory is equipped with two CDC-6600, one IBM 360/65, and a Burroughs (B) 3500 Computer.

Language

The following language may be used at this facility:

1. COMPASS
2. FORTRAN
3. COBOL

4. SORT/MERGE
5. MARS VI
6. MIMIC

The laboratory is a member of VIM (CDC-6600 User's Group) and therefore has access to the entire VIM User's Library.

<u>Input/Output Options</u>

1. Card Readers (1200 CPM)
2. Card Punch (250 CPM)
3. Line Printers (1200 LPM)
4. Mag Tape Drives (7 and 9 track)
5. Multiple Disc Drives (2.86 by 10^6 characters).

<u>Realtime/Interaction</u>

77 operating input terminals. Total capacity unsurpassed within DoD.

DISTRIBUTION

Turnaround time is highly dependent upon the amount of data required for a test (minimum - realtime).

The data reduction and computational capabilities residing in the Computer Sciences Laboratory of the ADTC are so extensive* as to prohibit comprehensive description in this document. Potential users desiring more detailed information should request a copy of the document "Data Reduction and Computational Capabilities," dated September 1974, published by the Armament Development and Test Center, Eglin Air Force Base, FL 32542.

*Unsurpassed within DoD.

ANNEX B - INTRODUCTION

OVERVIEW

The U.S. AFFDL (Air Force Flight Dynamics Laboratory) is located at Wright-Patterson AFB, OH. The mission of AFFDL includes responsibility for non-nuclear aircraft survivability. The ballistic testing portion of the AFFDL mission takes place in the ASRF (Aircraft Survivability Research Facility). The ASRF consists of three test complexes used to: (1) support development of aircraft technology and design criteria, (2) evaluate development concepts, (3) validate production design, and (4) furnish rapid laboratory response to high-priority operational problem areas. The goal in this area is to provide proven design criteria for optimizing the survivability of combat aircraft to gunfire and missile threats encountered on a combat mission. The primary contact for this facility is Mr. R. W. Lauzze (AFFDL/FES), telephone 513-255-5264.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

AFFDL has concentrated much of its survivability testing efforts on wing and fuselage fuel cell testing. Structures and armor as well as small electronic and hydraulic packages are also tested routinely.

A significant developmental effort by the Air Force was the application of the survivability design criteria to the A-X prototypes. The A-X design criteria were based on test data from AFFDL facilities. As a result survivability features of the A-10 aircraft production design were then validated in AFFDL facilities. More recently, the A-7 fuel tank vulnerability evaluation program was conducted in the laboratory facilities. Survivability test programs have also been conducted in support of the B-1 and F-15 aircraft development.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The AFFDL ASRF, consists of three test complexes designed to provide a wide range of high realism test data on the survivability/vulnerability of aircraft using gun threats (up to 37-mm) in varying degrees of simulated in-flight environments. Range 1 is an indoor range used for the development and calibration of test ordnance and threat simulation techniques as well as investigation of terminal threat effects and armor evaluation.

Range 2 is an outdoor range used for evaluating the vulnerability of small flammable or explosive onboard stores and armor supporting structures. Limited testing of threat guns up to 37-mm have been conducted on this range.

Range 3 consists of a horizontal and vertical range capability. The horizontal capability resembles a standard outdoor 60-foot range. The vertical range, however, uniquely can test both air-to-air and ground-to-air threats against aircraft target sections in airflow of up to 550 knots.

Projectile sizes of between 30- and 85-mm normally are tested at remote Ohio National Guard ranges in Ohio and Camp Grayling, MI.

ACCESS

The AFFDL is located northeast of Dayton, OH, close to the intersection of Interstate Highways 70 and 75. Primary access to Area B, Wright-Patterson AFB, is either via Springfield Street on the north or Colonel Glenn Highway (U.S. 444) on the south.

Several spurs of the Erie Railroad are available on the installation. The Central and St. Louis Railroad connections also are available.

Runways capable of accommodating all military and commercial transport aircraft are located on Area A of the base. Wright-Patterson AFB, Area A is approximately 5 miles northeast of Area B. The Area B runways are used to a very limited extent (east-west runway length approximately 7147 feet).

MAINTENANCE/FABRICATION CAPABILITIES

AFFDL has limited maintenance facilities to support ballistic tests. In addition, the base maintenance and fabrication shops can provide one-of-a-kind construction and repair support. An ammunition loading room is available in Building 4067.

LOGISTICAL SUPPORT CAPABILITY

Logistical support is available from base and laboratory resources.

INDOOR FACILITIES

RANGE 1

Dimensions

Range 1 is a 10 ft^2, indoor, horizontal tunnel 275 feet in length. A large (21- by 27-foot) work area is located at the launcher end of the range. The target arena can be totally enclosed to eliminate any natural light and provide for better measurement of flash intensity of high velocity impacts. The test specimen size is restricted by the dimensions of the door.

Weapon/Projectiles Available

Range 1 can accommodate test weapons up through 23-mm API projectiles as indicated in Tables B-1 and B-2.

Environment

No environmental simulation other than application of static load is available.

Live/Inert Fire

Only ball, AP, API, and incendiary projectiles are allowed.

Safety (and Security) Requirements

The entire range is located in a secure area. Signs, red lights, and public address systems are available to warn personnel in the area when gunfire tests are in progress.

Classified weapons and/or target material can be stored in the gun vault located across the hallway from the range.

Power Availability

Electrical power ranges from 110 to 440 VAC are available in the range building. Also, a 60-kVA portable generator can be used if necessary. Pneumatic and hydraulic power are also available within the facility.

Observation/Communication

Tests are coordinated from the Gun Range 1 Control Room (Room OA-31, Bldg. 45). CCTV (closed circuit television) is used to monitor tests.

No direct observation of tests by personnel is allowed. Intercom communication is available to aid in test setup.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photographic coverage is provided by the 4950th Test Wing's Photographic Section. High-speed black and white and color cameras (up to 27,000 frames/sec) are available to monitor projectile motion and impact characteristics.

Flash x-ray and light screen velocity meters can be located the length of the range. Flash x-ray is used primarily for stop-action spatial and attitude measurements including orthogonal views. Flash x-ray velocity accuracies, however, of 0.001 ft/sec are possible. Light screen and paper chronographs are also available to monitor projectile velocities.

Laser boresight capability exists for measurement of the angle of obliquity of the target with respect to the gun barrel line-of-sight to accuracies of 1 degree.

TIMING. Sequencing counters are used for time correlation for gun and instrumentation functions.

HARDWIRE/TELEMETRY. All gun function and target-related transducers are hardwired to the control room for data recording. Printed circuit (paperbreak) velocity measurement is used as the velocity baseline on most Range 1 tests. Accuracies of from 5 to 10 ft/sec can be achieved by the printed circuit method and is normally used as the velocity baseline.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Flash x-ray and high-speed photography are the principal terminal ballistic instrumentation for the range.

The 16-mm Fastex camera with a speed of 7000 (27,000 maximum) frames/sec normally is used for high-speed camera support.

C-5 Polaroid cameras are used to record oscilloscope presented information, especially for flash intensity tests.

Photographic support is provided by the Technical Photo Section of the 4950th Air Force Test Wing. Turnaround time for photographic data is 10 days to 2 weeks normally, with 24 hour service available on a priority basis.

TIMING. Sequencing counters are used to control the firing of the weapon and the cameras. Printed circuits and light screens are used to trigger counters in the chronograph system and the flash x-ray. Dual sequencing counter instrumentation using the gun fire signal assures proper timing/sequencing control.

HARDWIRE/TELEMETRY. All critical target impact/stress/strain functions are monitored in hardwired instrumentation in the control room.

Environmental Simulation and Measurement

The ASRF Range 1 currently can be operated only at ambient air pressure, humidity, and temperature conditions.

OUTDOOR FACILITIES

Impact Ranges 2 and 3 are basic outdoor ranges of the ASRF. For testing of larger projectiles in the 57-mm range, however, remote ranges are used. These remote ranges are located at Lockborne AFB, OH, as well as Camp Grayling, MI.

IMPACT RANGE 2

Dimensions

The ASRF Range 2 is a 100-yard-long horizontal outdoor range. The terminal arena measures 26 feet in width, 24 feet in height, and 27 feet in depth and is a poured concrete arena with wall thicknesses of 12 inches. This range is adjacent to and shares the ASRF Range 3's instrumentation and control system.

Weapons/Projectiles Available

Range 2 is limited to 37-mm HE warheads. Tables B-3 and B-4 present gun sizes and fragment simulation capabilities, respectively.

Although 37-mm projectiles can be fired on the range, most 37-mm tests are conducted at Camp Grayling, MI.

Environment

Due to the outdoor nature of this test facility, only ambient conditions in terms of pressure and wind velocity can be accommodated. Temperature conditioning of the target can be accommodated on a limited basis.

Live/Inert Fire

AFFDL is limited to the use of explosive ordnance through 37-mm HE projectiles in Area B of the base. Both HEI and HEIT rounds can be tested in this range.

Safety (and Security) Requirements

CCTV operated from the blockhouse is the prime safety circuit for this range. In addition, lights, horns, and loudspeakers warn personnel in the area of pending gunfire tests.

The entire range is within a secure Air Force installation. Classified storage is available on base for all sizes of hardware.

Power Availability

110, 220, and 440 VAC are available at Range 2. In addition, a 60-kVA electric power generator can be brought in to provide other required voltages. A 1000-kVA transformer supplies normal range power.

Observation/Communication

CCTV, both color and black and white, is available in the blockhouse. This provides direct observation of items under test in either Range 2 or 3. Voice soundtrack is available on all CCTV tapes. All range operations are coordinated through the control trailer. CCTV and an intercom system provide realtime visual and audio data.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Fastex cameras (fast frame rate) and Hulcher cameras (slow frame rate) are used to record in-flight ballistic data. Photographic turnaround time is approximately 10 days to 2 weeks with 24 hour service available on high priority tests.

TIMING. IRIG-B time code generators, electronic counters, and verbal count-down communications provide time correlation for each test.

HARDWIRE/TELEMETRY. All gun functions, in-flight velocity meter measurements, and terminal information are monitored on magnetic tape recorders located in the instrumentation van. All data are recorded on constant bandwidth discriminators.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Most terminal ballistic events are recorded on cameras with rates of 7000 frames/sec provided by the 4950th Test Wing. Once more, photographic turnaround time is approximately 10 days to 2 weeks, with 24-hour service available on high priority test programs.

A laser boresighting capability is also available on all ranges to meausre the angle of obliquity of the target with respect to the gun's line of fire. Accuracy of 1 degree is obtainable with the laser system.

TIMING. IRIG-B time code generators, electronic counters, and verbal count-down sequence information provide time correlation for each test.

HARDWIRE/TELEMETRY. All hardwire instrumentation is channeled into the blockhouse for information from Ranges 2 and 3. For example, a 20-channel temperature continuous monitor capability is available for measurement of target temperature variations. In addition, a 32-channel strain gage capability is available to determine the target component load outputs. A HP (Hewlett Packard 2100S mini-computer is used to monitor instrumentation and provide output in terms of oscillograph recorder data.

Environmental Simulation and Measurement

There is limited environmental simulation or control in Range 2. The limits are test fuel conditioning and fuel circulation. In the case of hydraulic subsystem testing, these components can be tested while in the operational mode.

IMPACT TEST RANGE 3

Dimensions

The Range 3 complex consists of a horizontal and a vertical range. The horizontal range is a standard 60-foot outdoor range with the gun placed below and at right angles to the Vertical Gunfire Airflow Test Arena.

The Vertical Gunfire Airflow Test Arena is a poured concrete building, 39 feet high, 40 feet long, and 25 feet deep. Figure B-1 shows the general orientation of the range. Both air-to-air and ground-to-air gun platforms are available. Two TF 33-P-5 turbofan engines provide 500 pounds of air per second through a 9 ft^2 nozzle at velocities of up to 550 knots. In addition, this air system has the capability to split the airflow to simulate aircraft engine inlet duct conditions and, concurrently, simulate in-flight airflow.

Test specimen sizes which can be accommodated in the vertical test arena range from a fuselage section 15 feet long and 6.5 feet wide to a wing span 8 feet long. Remotely controlled loading devices can accommodate various wing twists and flexures. Fuel cells of up to 500-gallon capacity can also be tested in this facility.

Weapons/Projectiles Available

As shown in Table B-5, Range 3 can handle up through 30-mm launchers; it can simulate both gun-fired and missile-launched fragment threats, as indicated in Table B-6. The range can also simulate multiple hits of 23-mm guns.

Environment

Airflow ranging in velocity from 40 to 550 knots can be produced over the test specimen through a 33- by 36-inch duct using two TF 33-P-5 turbofan engines. The simulated in-flight airflow is produced by ducting the turbofan bypass air into the test area. Airflow control accuracies are ±5 knots, with as much as a 5-knot velocity fluctuation at the upper end of the velocity regime. Airflow can be split and a portion diverted to simulate engine inlet conditions. A fuel temperature conditioning capability ranging from between 0° to 110°F at shot time (±5°F) is available for both wing and fuselage fuel cells. Liquid air can be injected into the stream flow to observe flow characteristics.

Live/Inert Fire

Range 3 is limited to the use of explosive ordnance up through 30-mm HEIT projectiles. Range 3 can simulate fragmentation threats from larger projectiles and missile warheads. Stand-off distance and the requirement to pre-arm the projectiles are limitations of this range.

Safety (and Security) Requirements

A combination of CCTV, IR scanners, and thermocouples provide monitoring instrumentation for possible specimen fires. In addition, lights, horns, and loudspeakers warn personnel in the area of gunfire tests.

Carbon dioxide and water deluge are available to extinguish specimen fires.

The entire range is within a secure Air Force installation. Classified weapons can be stored on the base.

Power Availability

110, 220, and 440 VAC, 60-cycle power is available from a 1000-kVA transformer. Other voltage and frequencies are available through the use of portable generators. Hydraulic and pneumatic generators are available from the laboratory, if required.

Observation/Communication

CCTV (color and black and white) with voice soundtrack is used to monitor the test. TV monitors, intercoms, loudspeakers, and telephones are available in the blockhouse.

In-Flight Ballistic Instrumentation

Some in-flight data can be obtained from the terminal ballistic instrumentation (there is no truly in-flight ballistic instrumentation).

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. 16-mm Fastex cameras (7000 frames/sec) and 16-mm Milliken cameras (64 to 500 frames/sec) are used to record fast and slow frame rate test data, respectively. Special cameras can be employed to monitor unusual events such as fuel being dumped into the engine inlet from a ruptured tank.

Photographic processing turnaround time is 10 days to 2 weeks, normally, and 24 hours with priority.

A laser sighting capability is available to measure the angle of obliquity of the target with respect to gun's true line of fire with accuracies of 1 degree.

TIMING. IRIG-B time code generators, electronic counters, and verbal countdown provide time correlation for each test.

HARDWIRE/TELEMETRY. All instrumentation is hardwired to the blockhouse for recording, monitoring, and display. These hardwired items include temperatures (specimen and airflow), projectile velocities, pre-impact test specimen conditions, hydraulic ram pressures, airflow, shock, and other ballistic parameters, as required.

A combination graphite/strain gage and paper chronograph velocity measurement system is used for measuring velocity in the vertical test facility. Other special purpose instrumentation systems can be designed and built as required.

The blockhouse contains the following equipment: HP 2100S mini-computer with 32K core storage and 64 channels of analog-to-digital conversion; 14-channel FM tape recorder; 12-inch oscillograph; 7-inch oscillographs; electronic counters; time code generators; signal conditioning; ASR 33 teletype; and 20-channel temperature recorder.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

On-site data processing is provided. The HP 2100S mini-computer is used to record steady-state data such as temperature, flow rates, pressure, and velocity.

Three dual-trace oscilloscopes are available with cameras to record data photographically.

QUICK-LOOK CAPABILITIES

CCTV, photographs, digital counters, temperature recorder, oscillographs, and teletype hard copy provide selected quick-look data.

PROCESSING

Data processing is done by either using the HP 2100S mini-computer or Air Force CDC-6600 system.

DISPLAYS

Realtime display is provided by color and black and white CCTV.

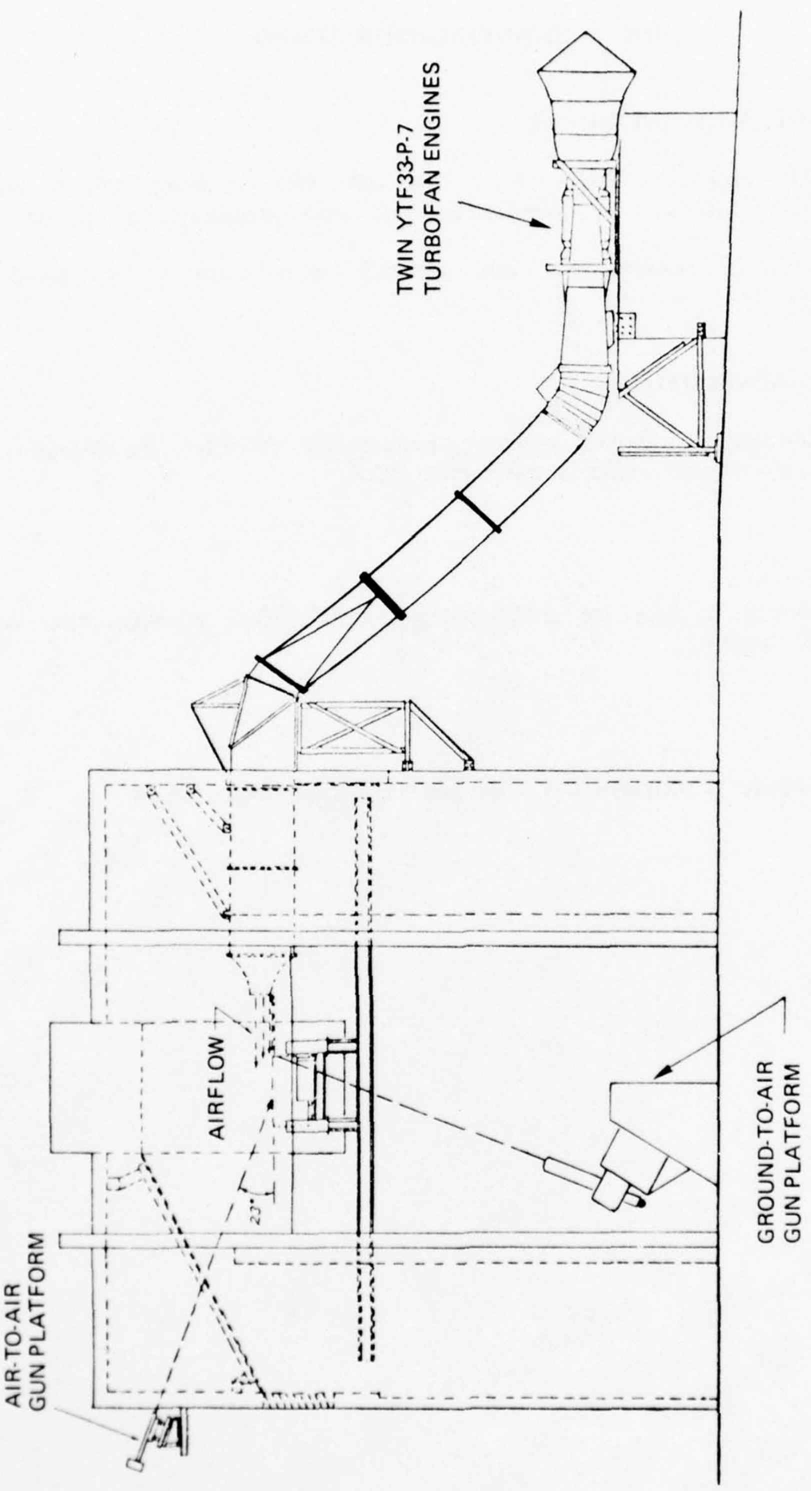

Figure B-1. Vertical Gunfire Airflow Test Facility.

Table B-1. Gun Sizes.

Domestic	Foreign, mm
5.56-mm	7.62
30 caliber	12.7
50 caliber	14.5
60 caliber	23
20-mm	

Table B-2. Fragment Simulation.

Smooth bore diameter	Fragment simulator sizes, grains		Velocity, ft/sec
5.56-mm/0.223 in.	17		5000
7.62-mm/0.308 in.	44		5000
12.7-mm/0.5 in/50 cal	207		5000
	80		5000
14.5-mm/0.6 in/60 cal	90		6000
	80 (sabot)		6000
20-mm/0.787 in.	180 (single or pair)		6000
	130 (pair or triplet)		5000
30-mm/1.18 in.	10	1 up to 480 frag/shot	6000
1, 2, 3, or 4 barrel	30	1 up to 124 frag/shot	6000
simultaneous firing	60	1 up to 56 frag/shot	6000
	120	1 up to 40 frag/shot	6000
	240	1 up to 12 frag/shot	6000
	30/rod	1 up to 64 frag/shot	6000

Table B-3. Gun Sizes.

Domestic	Foreign, mm
5.56-mm	7.62
30 caliber	12.7
50 caliber	14.5
60 caliber	23
20-mm	30
30-mm	37

Table B-4. Fragment Simulation.

Smooth bore diameter	Fragment simulator sizes, grains	Velocity, ft/sec
5.56-mm/0.223 in.	17	5000
7.62-mm/0.308 in.	44	5000
12.7-mm/0.5 in/50 cal	207	5000
	80	5000
14.5-mm/0.6 in/60 cal	90	6000
	80 (sabot)	6000
20-mm/0.787 in.	180 (single or pair)	6000
	130 (pair or triplet)	5000
30-mm/1.18 in/GAU 8	180	6000
	600 (sabot)	6000
30-mm/1.18 in.	10 1 up to 480 frag/shot	6000
1, 2, 3, or 4 barrel	30 1 up to 124 frag/shot	6000
simultaneous firing	60 1 up to 56 frag/shot	6000
	120 1 up to 40 frag/shot	6000
	240 1 up to 12 frag/shot	6000
	30/rod 1 up to 64 frag/shot	6000

Table B-5. Gun Sizes.

Domestic	Foreign, mm
5.56-mm	7.62
30 caliber	12.7
50 caliber	14.5
60 caliber	23
20-mm	30
30-mm	

Table B-6. Fragment Simulation.

Smooth bore diameter	Fragment simulator sizes, grains	Velocity, ft/sec
5.56-mm/0.223 in.	17	5000
7.62-mm/0.308 in.	44	5000
12.7-mm/0.5 in/50 cal	207	5000
	80	5000
14.5-mm/0.6 in/60 cal	90	6000
	80 (sabot)	6000
20-mm/0.787 in.	180 (single or pair)	6000
	130 (pair or triplet)	5000
30-mm/1.81 in./GAU 9	180	6000
	600	6000

ANNEX C - INTRODUCTION

OVERVIEW

The AMMRC (Army Materials and Mechanics Research Center) is located in Watertown MA, and is the major materials research and development arm of the U.S. Army Materiel DARCOM (Development and Readiness Command). AMMRC is responsible for conducting theoretical and applied research in materials, such as metals, ceramics, plastics and composites, and materials processing, such as melting, casting, fabricating, joining, and coating. AMMRC also is assigned as the Lead Laboratory for Armor Materials Technology. Most of the AMMRC programs are undertaken to meet specific Army requirements, but AMMRC also serves as an overall breeding ground for new and advanced type materials and materials technology for the Department of Defense.

Ballistic test facilities at AMMRC are under the Process Development Division of the Materials Development Laboratory, the Engineering Mechanics Division of the Mechanics Research Laboratory, and the Polymers and Chemistry Division of the Organics Materials Laboratory. Dr. Frank R. Larson is Chief of the Materials Development Laboratory, Mr. Joseph Bluhm is Chief of Mechanics Research Laboratory, and Dr. George Thomas is Chief of the Organic Materials Laboratory. The primary points of contact for AMMRC ballistic testing and evaluation are Mr. Francis C. Quigley, Chief, Process Development Division (DRXMR-ER), telephone 617-923-3115; and Mr. Francis S. Mascianica (DRXMR-ER), telephone 617-923-3436.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The AMMRC ballistic test facilities are primarily of the laboratory variety and generally are not used for service type testing, such as that required to determine aircraft system or subsystem vulnerability. However, AMMRC does assist in special problem solving and compatible research areas. Materials testing of almost any nature can be performed for new or modified materials, as well as components of interest for applicability to aircraft systems. Aircraft structural or other material related components, such as armor seats and improved rotor blade materials, are the most compatible with the AMMRC capabilities and mission.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Six ballistic test facilities were reviewed, all classified as indoor, terminal ballistic facilities. Four enclosed firing ranges, one open light gas launching facility, and one enclosed explosion chamber provide firing lengths ranging from 20 to 50 feet and the capability of statically detonating HE charges up to 0.5-pound HE.

ACCESS

AMMRC is located on the north bank of the Charles River in Watertown, MA, approximately 5 miles west of Boston, just north of the Massachusetts Turnpike (Interstate 90) on Arsenal Street.

No railroad access is available on post although a helipad is located on post for helicopter access.

The Logan International Airport is located approximately 6 miles east of AMMRC and can be reached via Soldiers Field Road, Storrow and Memorial Drives, and the Massachusetts Turnpike. U.S. Air Force Hascom Field is located in Bedford, which is approximately 8 miles northwest of AMMRC and can be reached on Route 128.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capability at AMMRC is excellent. Full machine shop facilities are available for the fabrication, maintenance, and modification of weapons, projectiles, test materials, and jigs and fixtures for securing aircraft armor or components.

LOGISTICAL SUPPORT CAPABILITY

The location of the AMMRC away from normal military facilities makes logistical support somewhat more difficult than might be expected at other ballistic test areas. All logistics items would have to be shipped in at least from a terminal port by road to AMMRC.

INDOOR FACILITIES

Four firing ranges, Ranges 1 through 4, are located adjacent to each other and are operated by the same personnel. Instrumentation and launchers are generally available to each range from a common facilities pool. Therefore, both instrumentation and launchers described for Range 1 will also be available on Ranges 2 through 4, within the weapon size constraints documented for each range.

RANGE 1

Dimensions

Range 1 is approximately 12 feet wide by 9 feet high, extending 50 feet to a sand-filled butt backed by a 0.5-inch-thick steel armor plate and a 12-inch-thick solid concrete wall. Most kinetic energy ammunition firing is done at target materials

approximately 30 feet from the muzzle, where several different target mounting fixtures are usually located. The full length of the range is available for use, if required.

Weapons/Projectiles Available

Weapons or projectiles up to 20-mm size may be fired in this range. An extremely large array of launchers, both rifled and smooth bore, and projectiles are available as off-the-shelf items. Both domestic and foreign launchers and projectiles are included. Fragment simulating projectiles used for armor acceptance tests, ranging from caliber 0.1 (1.35 grains) to 20-mm (830 grains) are also available. The technology and expertise are also available for launching unusual shapes, e.g., cubes, disks, actual shell fragments and flechettes, at velocity levels up to 8000 ft/sec. Controlled projectile tumbling or yawing can be accomplished.

A special target holding fixture, shown in Figure C-1, can be employed to apply stress to target materials during ballistic impact. Either tension or compression loading can be applied to material specimens up to 14 by 16 inches in size. Hydraulic pressure up to 2900 psi limits the loading. Heating or cooling can also be applied while loading the specimens.

Environment

Temperature and humidity extremes can be simulated for target materials. Projectile travel through rain and sand has also been simulated.

Live/Inert Fire

Firing at this facility is done primarily with inert rounds, although firing with incendiary projectiles can be conducted with 14.5- and 20-mm ammunition. No live HE firing may be done.

Safety (and Security) Requirements

Classified material and equipment can be accommodated easily in a large storage vault. Standard safety procedures are employed and are available from the AMMRC Safety Officer.

Power Availability

Normal 110 volt, 220 volt, 3-phase, and 440 volt single phase power is available at this range. Unusual requirements can be met with portable generators.

Observation/Communication

No direct observation of the range is allowed during firing.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Still and high-speed motion photography may be used. High-speed photographic capability consists of single and multiflash sources, high-speed framing cameras and x-ray photographic equipment. Shadowgraphs triggered by break circuits or Lumiline electronic screens can also be employed.

TIMING. Electronic counters of 0.1 to 0.2 μsec accuracy can be used with break circuit or Lumiline electronic screens for velocity measurement.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Still photographs of test specimens after impact are commonly taken. High-speed photographic capability is not maintained by the range itself, but if required can be provided by the AMMRC Photographic Services Branch.

Shadowgraphs or high-speed photographs of both before and behind the plate effects from ballistic impact can be taken. These can be triggered either by break circuits or electronic Lumiline screens.

TIMING. Break circuit and electronic Lumiline screens are used with electronic counters of 0.1 to 0.2 μsec accuracy for time measurements used to calculate striking and residual velocities.

TELEMETRY. Strain gage technology is available.

RANGE 2

Range 2 is identical in geometry to Range 1 with the exception that it terminates with a filled cinderblock wall, rather than a sand butt. A light gas gun is available in this range and the missile is launched into a test chamber. The gun and chamber are 45 feet long with a breech of 37-mm. Projectiles from fragment size up to 20-mm can be launched. The test chamber can be evacuated to simulate high altitude atmospheric conditions, if desired.

RANGE 3

Dimensions

Range 3 is approximately 8 feet wide by 9 feet high by 20 feet long with 1/4-inch-thick mild steel plate providing ballistic protection throughout the range.

Weapons/Projectiles Available

Projectiles, fragments, and fragment simulators from grenade (2-grain) fragment size up to .30-caliber fragment simulating projectiles (44 grains) may be fired in this range. Striking velocity of .30-caliber projectiles is limited to approximately

4500 ft/sec and the smaller .22 caliber to approximately 6000 ft/sec. All launchers up to and including .30 caliber that are available for use on Range 1 can also be used on Range 3.

Other capabilities of this range are identical to those described for through Range 1.

RANGE 4

Range 4 is identical in capabilities to Range 3 with the exception that range width is approximately 10 feet. For this reason high-speed motion photography is usually conducted in this range because the extra width allows more room for camera equipment and ballistic protection.

DETONICS FACILITY

Dimensions

The Detonics Facility is an "L" shaped enclosure of steel armor plate in which explosive charges may be detonated. The facility if 6.5 feet high with the shape and dimensions shown in Figure C-2. The shaded area, consisting of sand-filled retaining walls incorporating 0.5-inch steel armor, is covered on top and sides with blasting mats constructed from sections of rubber tires to provide both increased ballistic protection and reduction of noise levels below the tolerance level of 140 dB.

Weapons/Projectiles Available

Up to 1/2 pound of HE may be detonated in this facility. Shaped charges can also be accommodated. Fragmentation studies are currently being conducted using water-filled barrels for complete recovery of shell fragments.

Environment

No environmental simulation is done at this facility.

Live/Inert Fire

Live charges are detonated at this facility.

Safety (and Security) Requirements

Standard safety procedures are observed at this facility. A copy of pertinent procedural requirements (AMMRC procedure 385-21) can be requested from the AMMRC Safety Officer. Special arrangements would have to be made for any classified material or equipment.

Power Availability

Standard 110-volt, 220-volt, 3-phase, and 440 volt single phase power is available. Portable generators can provide for any special requirements.

Observation/Communication

No direct observation of tests is allowed.

In-Flight Ballistic Instrumentation

This item is not applicable for this facility.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Still photographs are taken of test results. A Hycam high-speed motion camera that operates at 11,000 frames/sec can be used to record action during tests. Additional high-speed motion photographic capability can be provided by the AMMRC Photographic Service Branch.

Flash x-rays may also be used to provide stop-action data.

TIMING. Timing information is provided by one trace on an oscillograph that can record overpressure histories on two additional traces.

TELEMETRY. One 14 channel and one 7 channel magnetic tape recorder can be used to record strain gage measurements.

LIGHT GAS LAUNCHING FACILITY

Dimensions

The Light Gas Launching Facility is not an enclosed firing range. The facility is currently housed in a laboratory area approximately 30 by 30 feet. While projectiles normally are fired a short distance (6 to 10 feet), the potential exists for firing over longer ranges, up to 35 feet if required.

Weapons/Projectiles Available

Cylindrical projectiles are launched using compressed helium at 1000 psi. Velocities that can be achieved are determined by the projectile mass with the largest projectile of interest being approximately .50 caliber launched at 500 to 600 ft/sec. Smaller projectiles may be launched at higher velocities. Target material specimens are normally less than 12 in^2.

Helium is stored at 3000 psi with pressure reduced to 1000 psi by a series of gages. Higher pressures (up to 3000 psi) could be used at the launcher by changing gages.

Environment

No environmental simulation is done at this facility.

Live/Inert Fire

No live fire may be done at this facility.

Safety (and Security) Requirements

Classified materials and equipment can be accommodated at this facility.

Power Availability

Standard 110 and 220 volt, 3-phase power is available.

Observation/Communication

Personnel conduct tests from an adjoining room. Direct observation of tests normally is not required.

In-Flight Ballistic Instrumentation

Due to the short firing ranges involved, no in-flight instrumentation is normally employed.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed motion photography and still photography are employed to record terminal ballistic effects. Flash x-rays (300 kV) and cameras can also be used to record both before and behind the plate terminal effects or projectile-target interaction.

TIMING. Timing is accomplished using electronic counters of μsec accuracy. Either paperbreak or electronic light screens are employed to determine striking or residual velocities.

TELEMETRY. Striking and residual velocities are measured using paperbreak techniques.

HARDWIRE. Pressure, temperature, and strain gage measurements may be recorded on oscilloscope or strip chart recorders.

OUTDOOR FACILITIES

AMMRC has no outdoor ballistic test facilities.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data collected in the form of photographs (optical, x-ray, shadowgraph) are manually reduced and can be keypunched onto computer cards and stored on magnetic tape.

QUICK-LOOK CAPABILITIES

Photographs can be processed within 30 minutes after completion of a test. Data reduction times are highly dependent upon the length of test, instrumentation configuration, and the amount of data to be extracted. An HP (Hewlett-Packard) programmable calculator with plotter and typewriter input is available for immediate use for processing data at Ranges 1 through 6.

PROCESSING

System and Model

AMMRC is served by a Univac 1106 digital computer that is physically located at Natick Laboratories, Natick, MA. Access to this facility is provided by two remote batch terminals on site at AMMRC. Data processing of large amounts of data is done on this computer.

An HP programmable calculator (Model 9810A) along with its calculator plotter (Model 9862A), cassette memory (Model 9865A) and FACIT output typewriter is used to process data at Ranges 1 through 4.

Language

FORTRAN IV and V may be used for the Univac 1106. A special symbolic coding language is used for the HP data processing equipment.

Input/Output Options

Punched cards or magnetic tape may be used for input or output on the Univac 1106. A high-speed line printer is also used for output.

Input for the HP calculator is punched directly into the machine. Output is either to a small thermoprinter, typewriter, or X-Y plotter (increments of 0.001 inch).

DISTRIBUTION

Turnaround time is highly dependent upon the nature of the test and the amount of data being collected. Test data reduction can be accomplished within 1 working day following a test. Black and white film can be processed within 1 hour and color film in 3 days following a test.

DISPLAYS

Plots can be generated by the HP programmable calculator with an X-Y plotter (increments of 0.001 inch).

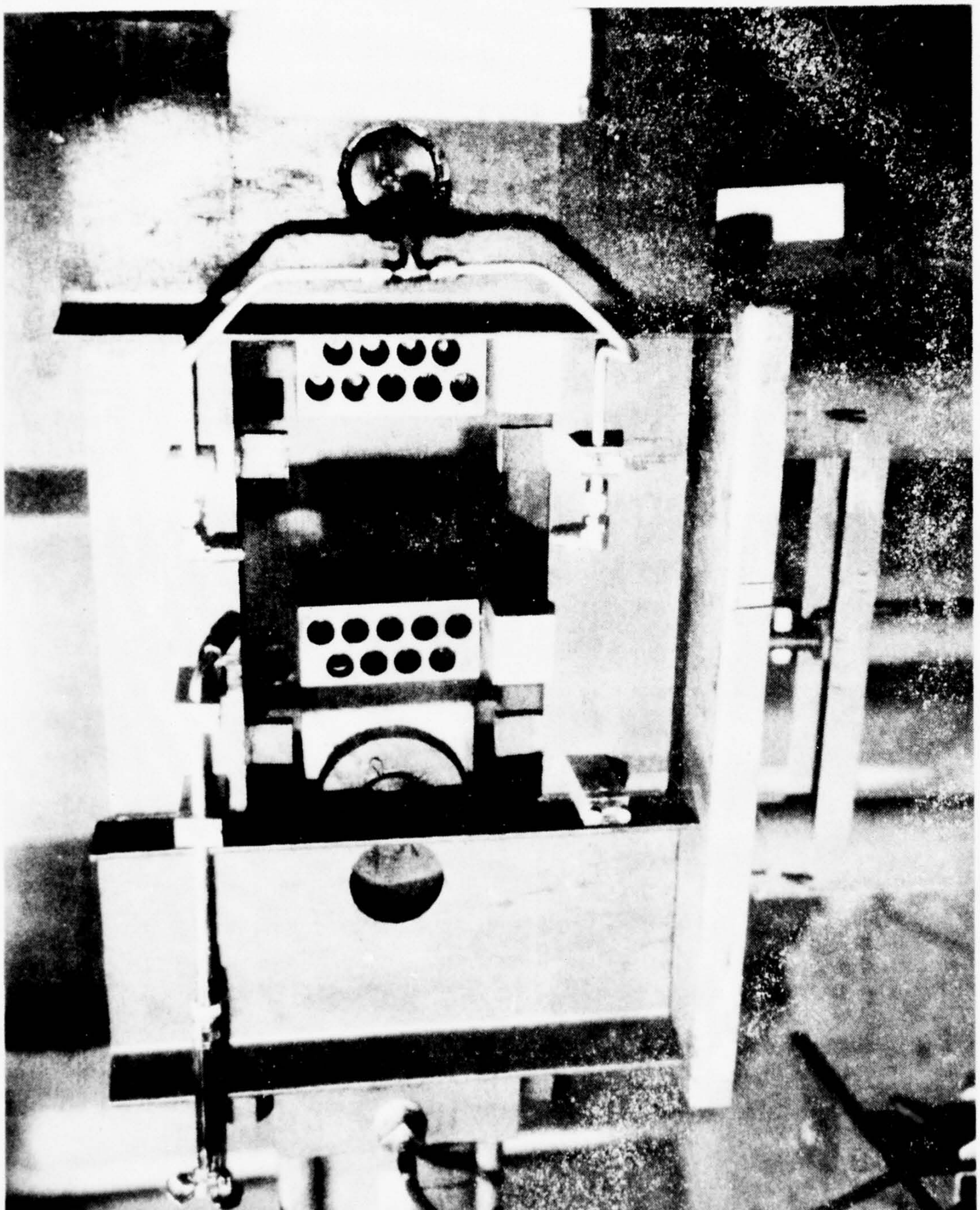

Figure C-1. Special Target Fixture.

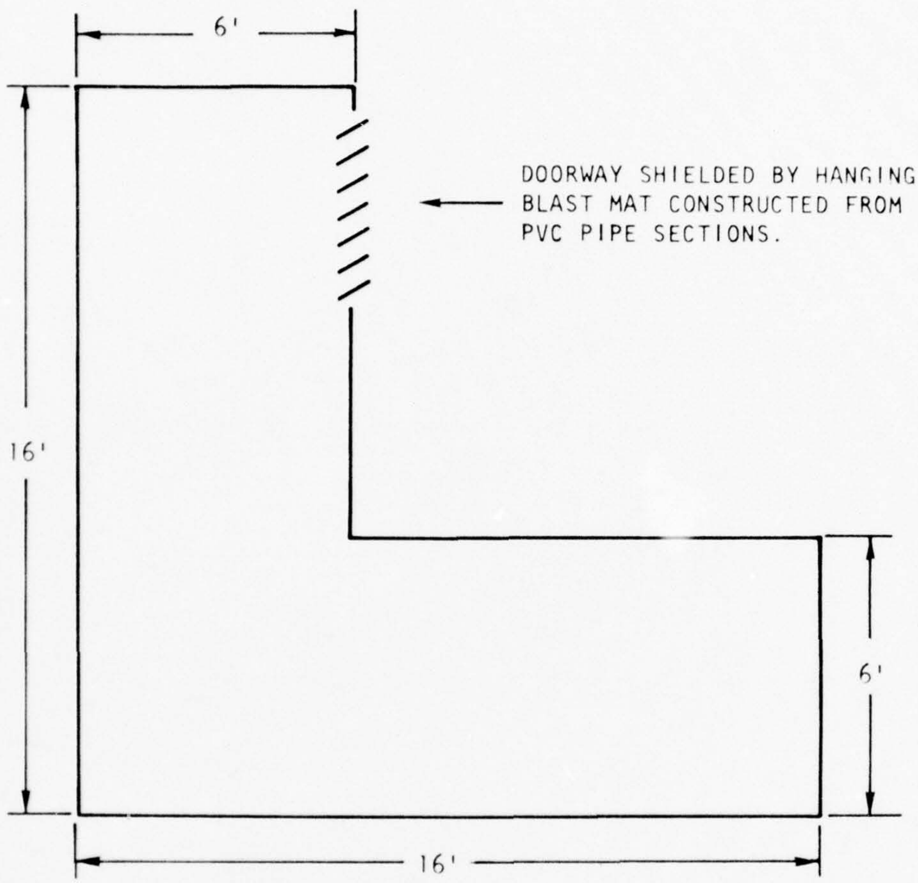

Figure C-2. Geometry of the Detonics Facility.

ANNEX D - INTRODUCTION

OVERVIEW

The U.S. Army AMRDL (Air Mobility Research and Development Laboratory) is the R&D (research and development) laboratory of the U.S. Army AVSCOM (Aviation System Command). The AMRDL headquarters are located at Ames Research Center, Moffett Field, CA, with laboratory elements located at Ames Research Center, Moffett Field, CA; Lewis Research Center, Cleveland, OH; Langley Research Center, Hampton, VA; and Fort Eustis, VA. The AMRDL is charged with the following mission:

1. Plan, develop, manage, and execute for the U.S. Army AVSCOM the research and exploratory development program and the advanced development program through demonstration of technology to provide a firm technical base for future development of superior airmobile systems.

2. Manage and direct on a task basis, as assigned by CG (Commanding General), AVSCOM, tasks in advanced and engineering development subsequent to demonstration of technology.

3. Maintain cognizance of, and provide consultative support for, advanced development subsequent to demonstration of technology, engineering development, operational development, and test for all Army airmobile systems.

4. Provide technical consultation and independent risk assessment to CG, AVSCOM, for systems and components under development.

The goal of the AMRDL R&D activities is to concurrently maximize mission capabilities and operational effectiveness of Army aircraft and minimize life-cycle costs. The laboratory's R&D program specifically addresses aircraft safety and survivability, propulsion systems, improved rotor and other subsystems, and reliability and maintainability.

The Eustis Directorate at Fort Eustis, VA, is organized into three research divisions (Military Operations Technology, Technology Applications, and System Support), and four support divisions. The ballistic test capability is in the Safety and Survivability Technical Area of the Military Operations Technology Division. Mr. J. Robinson, Head, Vulnerability and Protection Branch, telephone 804-878-3902, or Mr. C. M. Pedriani, in charge of range operations, are the primary points of contact for AMRDL ballistic testing.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The AMRDL Eustis Directorate is primarily oriented toward rotary-wing aircraft testing, but also has the capability for testing light fixed-wing aircraft. All rotary-wing aircraft systems and subsystems can be tested ballistically either as isolated components or installed in test-bed aircraft.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The AMRDL Eustis Directorate has one outdoor tiedown pad and one combination indoor/outdoor firing facility. The .30- and .50-caliber, and 14.5-mm AP and API projectiles may be fired at the combination indoor/outdoor facility and projectiles up to 23-mm HEIT may be fired at the outdoor tiedown facility. Test targets from small material specimens up through operating aircraft can be accommodated.

ACCESS

The AMRDL Eustis Directorate is located at Fort Eustis, VA (within the geographical boundary of Newport News, VA), on the east bank of the James River. It is reached via U.S. Route 64, exiting west on Virginia Highway 105. The main gate for Fort Eustis is located approximately 1 mile west of U.S. Highway 64. There is railroad access to the Chesapeake & Ohio Railroad. Felker Army Airfield is located on base, and Patrick Henry Airport is approximately 8 miles south of the base. Deep water seaport facilities are located on the James River adjacent to the laboratory.

FABRICATION/MAINTENANCE CAPABILITY

The fabrication and maintenance capabilities at the AMRDL Eustis Directorate are excellent. Full machine shop capabilities are available for fabrication, maintenance, and modification of operational experimental aircraft systems. The U.S. Army Transportation School is located at Fort Eustis and can provide additional repair and maintenance capabilities.

LOGISTICAL SUPPORT CAPABILITY

The location of the AMRDL Eustis Directorate at Fort Eustis assures the laboratory of excellent logistical support from the U.S. Army Transportation School. In addition, various Army Aviation Transportation and support units are also stationed at Fort Eustis.

INDOOR/OUTDOOR BALLISTIC TEST FACILITY

BALLISTICS RANGE

Dimensions

The Ballistics Range is a combined indoor/outdoor firing facility consisting of two remodeled vans which provide an indoor area approximately 50 by 24 feet. The van is divided by 0.5-inch armor plate into an instrumentation laboratory area and a firing range as shown in Figure D-1.

The indoor portion of the range is 12 feet wide by 27 feet long by 8 feet high. Projectiles are stopped by an armor plate, sand-filled backstop located at the end of the van.

On the outdoor portion of the range, projectiles can be fired up to 100 feet into a concrete block, earth-covered bunker approximately 8 feet wide by 11 feet deep by 10 feet high. An overhead door at the bunker end of the van can be opened to provide an inside firing position. The bunker floor is sloped toward the front so that fuel from ruptured fuel tanks will drain into an underground sump (immediately in front of the bunker) to reduce the fire hazard during fuel tank tests.

Weapons/Projectiles Available

The following projectiles may be fired at the Ballistics Range:

1. .30 caliber (rifled and smooth bore barrels)
2. .50 caliber (rifled and smooth bore barrels)
3. 14.5-mm (rifled and smooth bore barrels)

Only .30- or .50-caliber ball, AP, or API projectiles may be fired on the indoor portion of the range. Targets may contain no flammable liquids on the indoor range, but targets placed in the earthen bunker may contain up to 200 gallons of aviation fuel. (Limits for individual tests are established by range personnel on the basis of the fire hazards involved.)

A portable test fixture can be used to apply up to 1000 in-lb of torque to material specimens up to 4 feet long and 8 inches in diameter. A portable fixture capable of applying up to 50,000-pound tension loads on panels approximately 1 by 2 feet is also available at the range. The fixtures will maintain load during and after ballistic impact. Extensive materials test facilities are available in the Structures Tech Area, Technology Application Division.

Environment

Targets may be temperature conditioned using portable heating or cooling devices. There are no other environmental simulation capabilities at this range.

Live/Inert Fire

Only ball, AP, or API projectiles may be fired at this range facility.

Safety (and Security) Requirements

Range safety procedures are available upon request. Classified material and equipment can be accommodated.

Power Availability

Standard 110- and 220-volt, 3-phase power is available (400-ampere service). Portable generators provide for other power requirements.

Observation/Communication

Tests can be observed directly through viewing ports or on color video monitoring/recording equipment located at the site.

In-Flight Ballistic Instrumentation

No in-flight ballistic instrumentation is available at this facility.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photographic coverage of tests is provided by still and high-speed cameras with frame rates up to 18,000 frames/sec. Fastex cameras (1000 to 18,000 frames/sec), one Milliken camera (400 frames/sec), 10 Photosonic cameras (up to 1000 frames/sec), and a 75-mm Hulcher (up to 50 frames/sec) are available for use. Test results can also be recorded on two video tape color recording systems.

Additional photographic instrumentation can be provided by the laboratory's Photographic Instrumentation Section.

TIMING. Sequencing of the test events, i.e., instrumentation, photographic equipment, and gun firing, is accomplished through a programmable control system. The projectile velocity is recorded on chronographs with μsec accuracy. Light screens or grid paperbreaks are used to trigger the chronographs.

HARDWIRE. A Vidar Digital data logger with the capacity of recording 80 channels of K or J type thermocouple linearized data and 20 channels of other mV inputs at a scan rate of up to 12 channels/sec can be used. Data from this system can be reduced on line with a HP (Hewlett-Packard) realtime processor. Direct write oscillographs with a frequency response of 2000 Hz as well as magnetic tape, FM or direct, with a frequency response up to 20,000 Hz are available. A variety of transducers and signal conditioning are available, as is a memory scope for high-speed recording.

OUTDOOR FACILITY BTRACS (Ballistic Test Range, Aircraft Survivability)

Dimensions (Figure D-2)

BTRACS is a 100-ft^2 macadam pad with numerous tiedowns for securing rotary- or fixed-wing aircraft for testing. A 30-foot-high earthen embankment provides ballistic protection on three sides of the pad. Personnel protection is provided

by a movable armor-plate shield with vision block. Firing ranges of up to 150 feet could be provided if desired. Subsystems, systems, or entire aircraft (including full fuel tanks) may be tested at this facility.

Weapons/Projectiles Available

In addition to the projectiles fired at the Ballistics Range, 23-mm HEIT can also be fired here. The same launchers are used on both ranges. The test fixtures for applying torque, described for the Ballistics Range, can also be used at BTRACS.

Environment

This range is an open air range. A 12- by 50-foot building for personnel protection and data acquisition equipment and a 40- by 60-foot building for specimen assembly are located near the macadam pad.

Live/Inert Fire

Live fire is permitted at this range.

Safety (and Security) Requirements

Range safety requirements are available upon request. There are no facilities for storage of classified material or equipment at BTRACS, but provisions can be made for removing such equipment to a secure facility during nonworking hours.

Power Availability

A transformer is located at the facility with ample power distribution to all buildings as well as around the perimeter of the macadam pad itself.

Observation/Communication

Tests can be observed directly through a vision block in the personnel shield or through either of the two color video monitoring/recording systems. Range personnel use portable communication devices for necessary communication between pad and instrumentation areas.

In-Flight Ballistic Instrumentation

No in-flight ballistic instrumentation is used at this range.

Terminal Ballistic Instrumentation

All instrumentation used on the Ballistics Range can also be used on BTRACS.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL (Figure D-3)

Data reduction from photographic test coverage is done manually. Data can be keypunched onto computer cards for computer data analysis. Data can be stored on magnetic tape or punched cards.

QUICK-LOOK CAPABILITIES

Extensive data acquisition/processing equipment is located on-site. A Textronix 4051 with hard copy unit and a Biomotion Wave Form Analyzer permit on-the-spot analysis of batch data and selected high frequency information. Magnetic tape playback onto oscillograph paper can also be accomplished. The color video recordings from two camera positions can be previewed immediately in slow- or stop-motion through dual monitors or through a special effects generator to a single screen.

PROCESSING

System and Model

Time-sharing access is readily available to an IBM 360/65 system (U.S. Army Aviation Systems Command, St. Louis, MO), CDC-6600 (Picatinny Arsenal, Dover, NJ), and a Univac 1108 system (Edgewood Arsenal, Edgewood, MD). Several HP and Wang programmable calculators are also available.

Language

FORTRAN IV can be used on the IBM, CDC, and Univac systems. A special symbolic coding language is used for the HP and Wang calculators.

Input/Output Options

Input/output is accomplished through a COPE 1200 batch RJE terminal with punched cards, magnetic tape, or high-speed printer.

Realtime/Interaction

Time-sharing access to the IBM 360/65 system is provided by a time-sharing 2741 TSO terminal.

DISTRIBUTION

Turnaround time for ballistic tests, data reduction, and processing is highly dependent upon the test configuration and the amount of data to be recorded and

reduced. Photographic coverage of a test can usually be provided within 1 day for black and white, and 2 to 7 days for color films.

DISPLAYS

Oscillograph traces, chronograph video tape records, and hard copy displays from the Textronix 4051 readouts provide immediate information on test results.

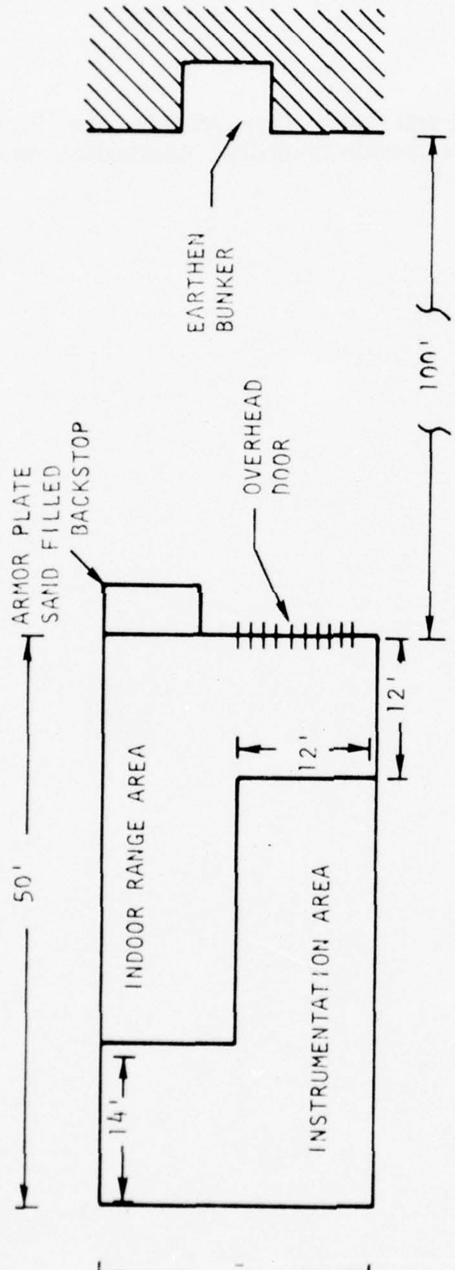

Figure D-1. Ballistics Range.

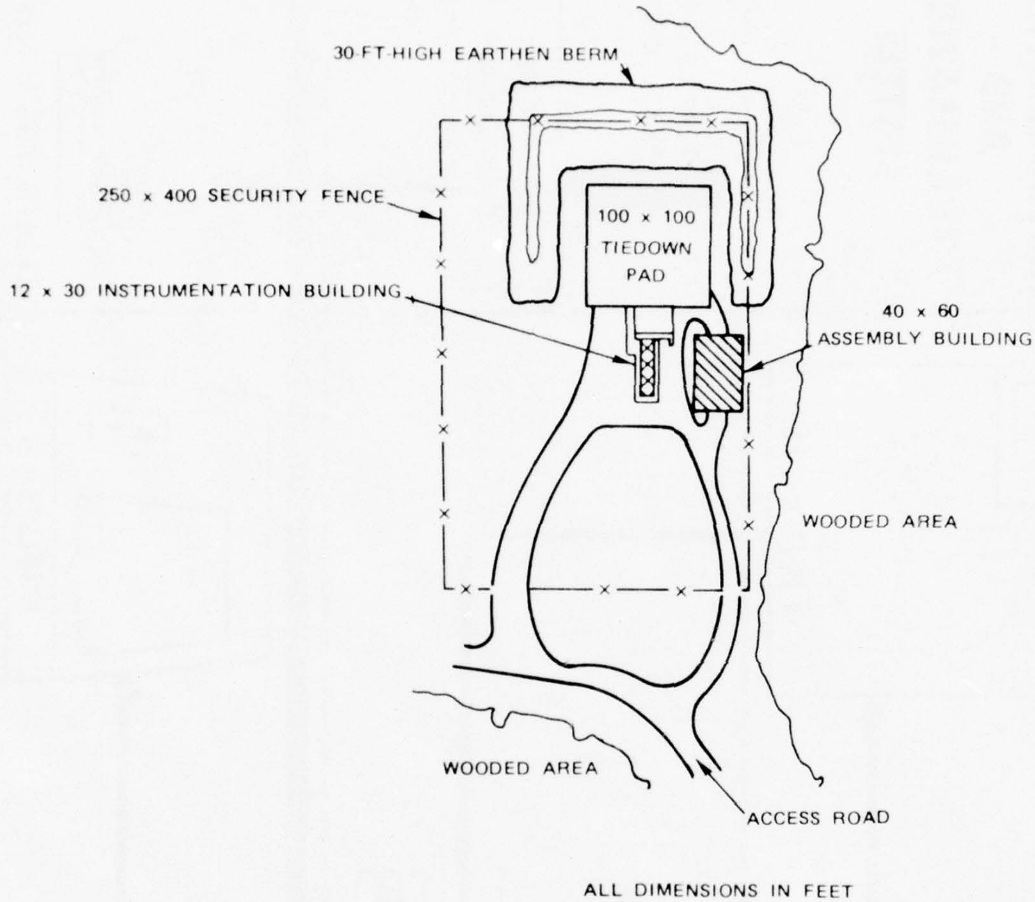

Figure D-2. BTRACS Facility.

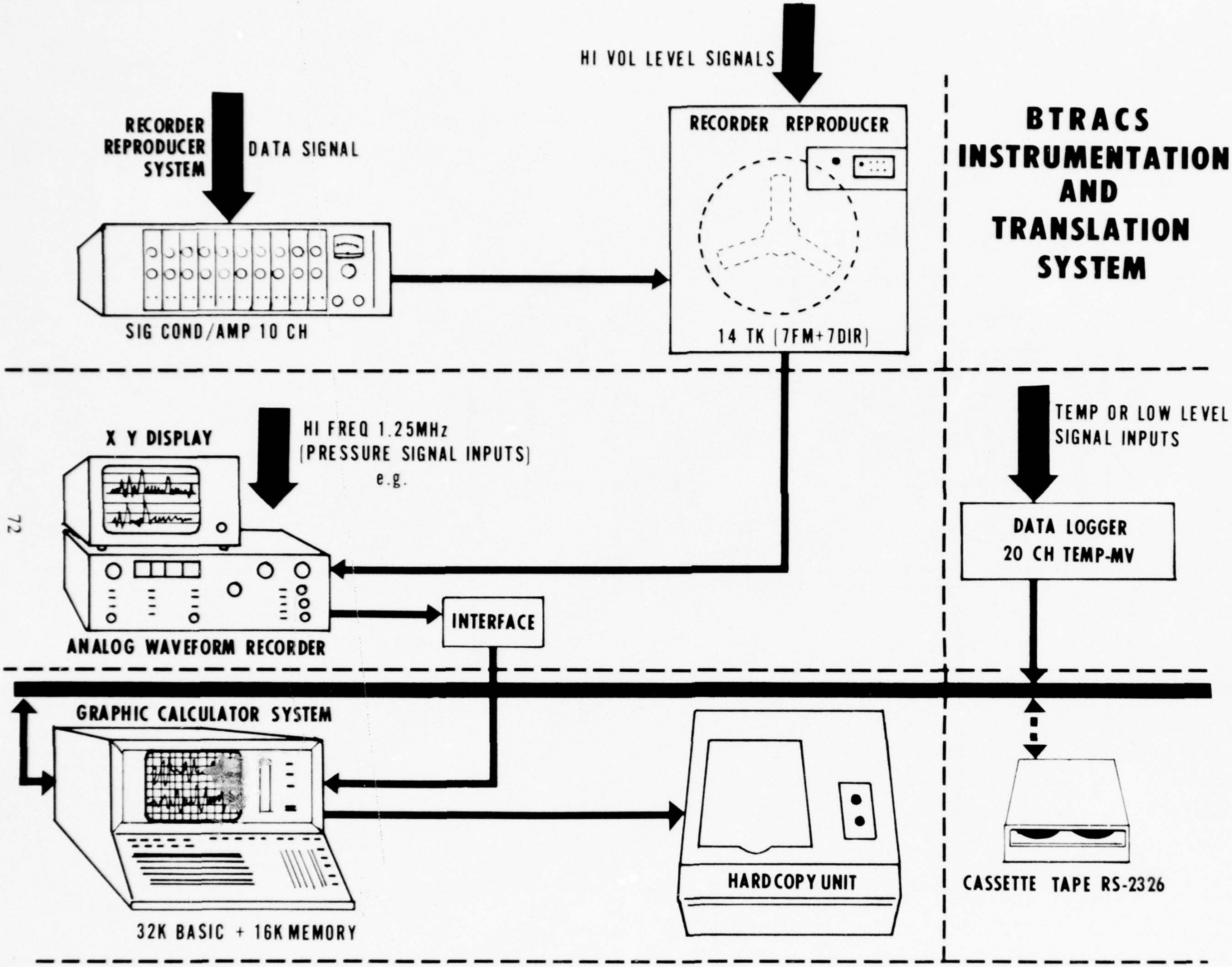

Figure D-3. BTRACS Instrumentation and Translation System.

ANNEX E - INTRODUCTION

OVERVIEW

The U.S. Army BRL (Ballistic Research Laboratory) located at Aberdeen Proving Ground, MD, has the mission to perform the functions of lead laboratory for ballistics and for vulnerability/vulnerability reduction. These functions are to establish and maintain a strong and viable weapons-oriented basic research program in physics, chemistry, mathematics, and engineering related to long-term Army needs and directed toward overcoming technological problems in defense-related technologies such as ballistics, vulnerability, communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials, and structures. In addition, BRL is responsible for evaluating foreign and domestic weapons and materiel systems and providing technical services to various commands of the U.S. Army Materiel Development and Readiness Command, the Department of the Army, the Department of Defense, and other government agencies.

Historically, BRL has been the center of weapon ballistic research for the Army. It has worked closely with the other services and their laboratories and centers to form the core capability in the ballistics and vulnerability areas.

From an organizational standpoint BRL is comprised of six different divisions along with a directorate for support services. The six laboratories are:

1. Propulsion Division
2. Launch and Flight Division
3. Terminal Effects Division
4. Warhead Mechanics Division
5. Vulnerability/Lethality Division
6. Ballistic Modeling Division.

The ballistic test facilities of interest for this survey are located in the VLD (Vulnerability/Lethality Division), the TED (Terminal Effects Division), and the WMD (Warhead Mechanics Division). The primary points of contact for the three laboratories are:

1. Mr. Richard Vitali, WMD, telephone 301-278-4706, DRXBR-WM
2. Dr. William Gillich, TED, telephone 301-278-2263, DRXBR-TE
3. Mr. Donald Mowrer, VLD, telephone 301-278-2878, DRXBR-VL (current chairman of the Vulnerability Assessment Subgroup of the JTCG/AS).

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

All types of rotary-wing aircraft systems and subsystems including airframe, flight controls, propulsion, fuel cells, and munitions have been tested routinely at BRL. Many fixed-wing aircraft tests have also been conducted.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Eight ballistic test facilities were reviewed during this survey. All eight of these facilities can be classified as terminal ballistic facilities for vulnerability testing since their primary orientation is toward the projectile-target interaction. Four of the BRL ballistic test facilities are outdoor facilities, and four are indoor facilities. Two of the indoor facilities possess unique capabilities for testing at a simulated high altitude.

ACCESS

Aberdeen Proving Ground and the BRL are located 30 miles north of Baltimore, MD, 5 miles east of the intersection of Interstate 95 and State Highway 22. In addition to road access both rail and airfield services are available on post. The capability to unload potential test items by using the Chesapeake Bay and seagoing vehicles exists but normally is not employed. Of particular value to the aircraft survivability program is the fact that Phillips Airfield, once an Air Force airfield, is located on post. It has a runway sufficient to land any aircraft including a C-5A. In close proximity to the airfield are a majority of the outdoor facilities used for terminal ballistic testing of aircraft subsystems so that aircraft can be flown in, stored nearby, and tests can be conducted keeping target preparation time to a minimum.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capability of BRL is extremely good, especially when considering that they can work in conjunction with the MTD (Material Test Directorate) of Aberdeen Proving Ground as well as the facilities of the U.S. Army Ordnance School, etc. Almost all types of field and operational maintenance as well as laboratory type fabrication can be supplied at Aberdeen Proving Ground.

LOGISTICAL SUPPORT CAPABILITY

Logistical support capability must be rated as one of the best of all the facilities surveyed since land, air, and rail service are supplied directly to the base. In addition, there are sufficient on-post operational support personnel and logistical support capability that many of the normal day-to-day logistics functions can be accomplished with little or no impact on the overall program. Lastly, the fact that the Aberdeen Proving Ground has many potential test items located on-post either in storage or on exhibit makes the availability of potential target material almost unlimited.

INDOOR FACILITIES

BLAST SPHERE FACILITY (VLD)

The Blast Sphere Facility is located on the extreme southeastern portion of Spesutie Island. The primary function of the blast sphere is to simulate high altitude detonations.

Dimensions

The spherical chamber is 30 feet in diameter with 2.75-inch-thick walls and has a 12-foot-diameter door large enough to accommodate many full-scale experiments. The facility can accommodate explosions of up to 8 pounds of HE (high explosive) at sea level conditions. Progressively larger sized detonations can be accommodated as the chamber is pumped down simulating an altitude increase. A 40-foot-long, 10-foot-diameter, terminal ballistic firing range is adjacent to the blast sphere. The two ranges can be connected or operated independently. The 40-foot range has a 4-foot-diameter access door to the cylinder. The 40-foot range is fabricated of 1/2 inch steel.

Weapons/Projectiles Available

Projectile launchers from 7 mm up to and including 57 mm can be mounted inside the cylinder and fired into the sphere. In addition, warheads equivalent to 8 pounds HE can be exploded within the sphere at sea level conditions. Up to 1 pound HE can be fired in the 40-foot cylinder at sea level conditions.

Environment

The blast sphere can simulate pressures down to 0.01-mm Hg, an altitude of approximately 175,000 feet. Both the cylinder and the blast sphere can be evacuated at the same time with the weapons firing taking place at any simulated altitude required.

Live/Inert Fire

The blast sphere and adjacent 40-foot range can accommodate live and inert fire. Instrumentation is available to handle all types of live firing; however, special provisions must be instituted to protect instrumentation from fragments when fragmenting projectiles are fired. These provisions are currently being reviewed and updated in connection with a future experiment to be conducted in the blast sphere.

Safety (and Security) Requirements

The standard safety operating procedures for the blast sphere are determined for each separate experiment to be conducted. There is no general standard operating procedure in terms of safety for the operation of the sphere, other than that one be established for each series of firings. The sphere doors and other open areas have safety interlocks to ensure range safety before any firing events can occur.

Classified weapon systems can be accommodated in both the blast sphere and the cylindrical range. Special procedures would probably have to be instituted to ensure complete security; however, the remote location plus the normal operating procedures for the range can accommodate this particular contingency.

Power Availability

Normal 110- and 220-volt, 3-phase power is available to the blast sphere and the ballistic cylinder. However, power outages can occur, particularly during the summer months, due to the demands of other facilities on the island. Improvements in power availability have been requested for future tests. In addition, generators can be obtained from Aberdeen Proving Ground to support particular tests with peculiar power supply requirements.

Observation/Communication

Some 32 viewing ports are available around this sphere. In addition, viewing ports are located along the ballistic chamber. These viewing ports are used to mount photographic instrumentation to be used in the post-test evaluation of the experiment. All operations are controlled from an instrumentation trailer located some distance from the blast sphere and the ballistic cylinder.

In-Flight Ballistic Instrumentation

The only in-flight ballistic instrumentation in the blast sphere or the cylinder is a portable paper screen velocity measurement device used to measure the time interval between the projectile breaking one paper screen and piercing the one further down the ballistic path.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The majority of the photographic instrumentation is combined in the use of three 500 frames/sec Hycam and 400 frames/sec Mitchell cameras. These cameras can be mounted in any of the 32 observation ports of the blast sphere or the cylinder.

TIMING. The only timing system available in this facility is timing of weapon functions. No attempt is made to time-correlate other events such as the photography and pressure measurements with gun functions.

TELEMETRY. The majority of the instrumentation other than the photographic type instrumentation is contained in the two 14-channel tape recorders for hardwire instrumentation both on weapon function and blast pressure propagation. These 14-channel recorders are high frequency and specifically tailored to blast pressure measurement recording.

Environmental Simulation and Measurement

Simulation of altitudes up to 175,000 feet can be accomplished in a relatively short time. The upper limit on altitude simulation is approximately 370,000 feet, which is well beyond any surveyed requirement.

INDOOR TEST FIRING RANGE (Range 161, Bldg. 390) (VLD)

The Indoor Test Firing Range is primarily a utility terminal ballistic facility for expeditious and efficient testing of components, materials and any other small targets (except HE and flammable fluids).

Dimensions

The Indoor Test Firing Range consists of three rooms: an observation room, a firing room, and a target room. Projectiles are fired a maximum distance of 35 feet into a sand butt in the target room.

Weapons/Projectiles Available

The Indoor Test Firing Range can accommodate launchers for projectiles up to 30 mm and fragments up to 500 grains. Both rifled and smooth bore launchers with diameters from 0.1 to 0.8 inches can be used for powder launch. Two-stage light gas guns with launcher diameters from 0.2 to 0.6 inches can also be used in this facility. Both foreign and domestic projectiles can be fired. No HE or HEI projectiles may be fired. Sabots may be used to launch various sized fragments or projectiles of less than 30 mm. Projectiles may be launched up to 3500 ft/sec; fragments may be launched up to 7000 ft/sec (or faster with light gas guns).

Special barrels are available for achieving controlled tumbling and yawing, if desired. Targeting at this facility is quite flexible. Virtually any target that can be accommodated by the range access door (36 by 80 inches) may be fired at. No flammable liquids may be tested in this facility.

Environment

Only ambient sea level atmospheric conditions can be accommodated by this facility.

Live/Inert Fire

No live HE projectiles may be fired in this facility. No fire into flammable liquids will be allowed at this facility.

Safety (and Security) Requirements

There is a standard safety operating procedure used for this facility and it is available at the BRL Safety Office. Classified material and equipment can be accommodated by this facility.

Power Availability

All major power options are available with generator capability also available for peculiar requirements.

Observation/Communication

Live observation of test firing is accomplished through viewing ports in the observation room.

In-Flight Ballistic Instrumentation

In-flight ballistic instrumentation normally is not installed in this facility.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed motion picture cameras, Fastex cameras with frame rates from 100 to 1000 ft/sec, record the tests from viewing ports in the observation room. The indoor range may be blacked out for acquisition of spark photographs, if desired.

Chronographs may be used to record striking velocity and residual velocities of projectiles. Additional chronographs may be used to record any other desired information. The accuracy of the chronographs is on the order of 1 ft/sec velocity. Both black and white and color photographs can be obtained, if desired. Spark photography and flash radiographs, along with recovery packs, can also be used, if desired. The recovery packs are constructed to the normal standards set by the three services and used, not only at BRL, but also at NWC and ADTC.

TIMING. Timing is usually of only secondary importance at this facility, but synchronization of cameras, chronographs, and gun functions could be accomplished.

TELEMETRY. Only larger events normally are telemetered or hardwire measured.

OTHER. Standard recovery packs are available for use in determining the size and penetration velocity of fragments. These standard recovery packs are subject to normal calibration requirements as established by a BRL memorandum.

Environmental Simulation and Measurement

No sophisticated environmental simulation or measurement equipment is available in this indoor facility, but target temperature can be varied by means of cold boxes or heating elements.

PENETRATION FACILITY (TED)

Dimensions

The Penetration Facility consists of two ranges. The first range is approximately 45 ft^2 and 10 feet high. Barrel-to-target distance is normally only a few feet. Projectiles are stopped with several feet of celotex backed by armor plate. The second range is 65 feet long by 10 ft^2 terminating in a sand-filled butt. Gun-to-target distance is usually under 10 feet, but the entire 65 feet are usable.

Weapons/Projectiles Available

Powder launchers are available in sizes ranging from .22 caliber to 30 mm. Fragment simulators and actual fragments are sabot launched. The Penetration Facility does a great deal of work in projectile development and currently is investigating a large array of rod penetrators. Material specimens, components, or targets up to several feet square can be used.

Depleted uranium projectiles may also be fired on this range.

Environment

Target materials can be temperature conditioned. No other environmental simulation is done.

Live/Inert Fire

No HE or incendiary projectiles may be fired.

Safety (and Security) Requirements

All firing is conducted from the fire control room just outside the range. An interlock system is used to prevent or interrupt firing when personnel are either in the terminal target area or the weapon firing room. Range safety operating procedures are available upon request.

Classified material or equipment may be stored at this facility.

Power Availability

Normal 110- and 220-volt, 3-phase power is available at the facility. Other power requirements can be met with portable generators.

Observation/Communication

No live observation of tests is allowed.

In-Flight Ballistic Instrumentation

No in-flight ballistic instrumentation is used.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Up to nine Field Emission Corporation 105 and 150 kVA x-ray units may be used on either range. They are normally used in pairs for orthogonal views. No high-speed photography is currently used, but can be made available if the need should arise.

TIMING. Electronic delays are used to trigger the x-ray units. Chronographs (0.1 μsec accuracy) and paperbreak are also used for striking and residual velocity measurement.

TELEMETRY. Strain gage technology is available.

Environmental Simulation and Measurement

Ovens and dry ice are available to temperature condition target materials.

RANGE R-7A (WMD)

Dimensions

Range R-7A conducts tests utilizing HE charges to determine the damage level induced by impacts from high velocity fragments on various material test specimens and aircraft components. The facility consists of two buildings and two firing sites, one indoor blast chamber, and one outdoor barricade. One building of approximately 800 ft^2 provides instrumentation and laboratory space and houses the blast chamber. The other building is used for preparation of HE charges.

The blast chamber is approximately 9 ft^2 with a 10-foot ceiling. This chamber, vented to the outside, is constructed of 1-inch armor plate backed by 2-foot-thick, reinforced concrete.

The outdoor barricade, approximately 12 ft^2 and 15 feet high, is constructed from 7-inch armor plate. It is open but provides shelter from inclement weather. Cabling for instrumentation runs from the barricade to the instrumentation building.

Firing range can be varied from 2 feet to approximately 9 feet.

Weapons/Projectiles Available

Fragments or simulated fragments from 2 to 2000 grains can be launched at velocities of up to 15,000 ft/sec using HE charges. Multiple fragment shots can be fired (up to thirty 20-grain fragments have been used). HE charge size and shape, fragment location, and detonation method determine the focusing of fragments.

Environment

No environmental simulation is done at this facility.

Live/Inert Fire

Fragment simulators are fired with HE charges.

Safety (and Security) Requirements

Range safety operating procedures are available upon request. Classified material or equipment can be accommodated.

Power Availability

Standard 110- and 220-volt, 3-phase power is available in the instrumentation building and blast chamber. Only that power used by the instrumentation (x-rays) is available at the barricade.

Observation/Communication

Tests in the blast chamber may be observed through observation ports. No direct observation of tests at the outside barricade is allowed.

In-Flight Ballistic Instrumentation

No in-flight instrumentation is used.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed motion cameras can be used to record test results. Fastex cameras with frame rates up to 4000 frames/sec are available. A Beckman Whitley Model 770 Streak Camera is also available, with writing speed up to 15 mm/μsec.

Up to eight x-ray photographs (four orthogonal pairs) may be used at either firing site. The x-ray units are 300 kV models. Striking and residual velocities may be measured as well as projectile orientation.

TIMING. Timing is done with oscilloscopes and electronic counters to μsec accuracy. The scopes are triggered by paperbreak or electronic light screens.

HARDWIRE. Pressure, temperature, and strain may be measured.

Environmental Simulation and Measurement

No environmental simulation is done at this facility.

OUTDOOR FACILITIES

TURBOJET ENGINE TEST FIRING RANGE

Dimensions

The Turbojet Engine Firing Range consists of an instrument block house, one large (fixed) engine test stand, several smaller mobile engine test stands, one concrete pad area and one macadam pad area. Large turbojet (or turbofan) engines can be accommodated on the test stands. Large or small helicopters may be tied down on the pad areas as test beds or targets. Engines can be tested while operating. An adjacent area, available for testing fuel cells, is especially arranged so that flammable fluids can be tested with a minimal amount of collateral damage.

Weapons/Projectiles Available

Projectiles up to and including 23 mm may be fired at engines, transmissions, and power train elements using either engine test stands or a tied down helicopter as a test bed. Pure blast may be generated using up to 1/2 pound of HE. Fragmentation rounds may be fired if fragments are properly constrained to ensure compliance with safety requirements. Fuel cells may be tested in an adjacent area using a TF-30 engine as an airstream source for fire tests.

Environment

Open air ambient atmosphere conditions are the only conditions available at this outdoor test facility.

Live/Inert Fire

Live fire is allowed but fragmenting munitions must be properly constrained to comply with standard operating procedures for safety.

Safety (and Security) Requirements

A standard operating procedure for safety is available in the Safety Office of BRL. A secure area can be created to handle classified equipment and material; however, since this facility is outdoors, it could require an indoor area at some adjacent facility near the Phillips Air Field.

Power Availability

Power is available up to 220-volt, 3 phase. Special requirements (engine starting, e.g.) are met by portable generators.

Observation/Communication

Tests may be observed from an instrumented block house using a CCTV (closed circuit TV) system.

In-Flight Ballistic Instrumentation

In-flight ballistic instrumentation is not available since projectiles are normally fired from launcher located immediately adjacent to the test stand. Normal launcher distances are from no more than 20 to a few feet away from the test article to minimize projectile dispersion.

Terminal Ballistics Instrumentation

LASER/PHOTOGRAPHY. High-speed motion cameras (32 and 64 frames/sec) and Milliken cameras (400 frames/sec) normally record the tests on either black and white or color film. Still photographs are also available.

TIMING. Blockhouse timing synchronization for gun and engine functions is obtained normally. Usually no attempt is made to synchronize cameras with other instrumentation.

TELEMETRY. All normal engine functions are measured and recorded on hard-wire instrumentation. Other special engine functions also can be recorded.

Environmental Simulation and Measurement

Only ambient sea level conditions are available at this facility.

UTILITY OUTDOOR RANGE (R-7A) (VLD)

Dimensions

The utility outdoor range consists of a gun mount located less than 100 feet from an armor backstop. This facility is situated on approximately 1 acre of land.

Weapons/Projectiles Available

A wide variety of launchers can be made available at this range up to and including 57-mm launchers. Fragments of from 15 to 240 grains can be accelerated from 7000 to 13,000 ft/sec. A special rig exists for firing at drive shafts and bearings under load and rotating at operational speeds. Target size is unrestricted. Projectiles can be accelerated to the hypervelocity range using two-stage light gas guns. Firings can be conducted at flammable fluids also.

Environment

This range is an open air facility.

Live/Inert Fire

Live fire may be employed in this facility including HE and HEI projectiles.

Safety (and Security) Requirements

Standard operating procedures for safety at this facility are available at the Safety Office of BRL. A secure area can be created to handle classified material and equipment; however, it would have to be located in an enclosed building somewhere in the Phillips Air Field area.

Power Availability

This facility can provide normal 110- and 220-volt, 3-phase power. Other requirements can be met with portable generators.

Observation/Communication

Observation and communication is controlled from a small permanent building on site.

In-Flight Ballistic Instrumentation

Paperbreak velocity measurement is normally used for in-flight ballistic information.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed motion cameras (Fastex cameras with frame rates of 100 to 1000 frames/sec) record test results.

TIMING. Chronographs are used to measure striking and residual velocities of the projectile. Gun and launcher function times, along with velocity measurements, can be recorded on a strip chart recorder in an instrumentation trailer.

TELEMETRY. Strip chart recorders are located in an instrumentation trailer.

OTHER. Standard recovery packs are available for use in determining the size and velocity of target penetrating fragments.

HELICOPTER MAIN BLADE BALLISTICS TEST FACILITY (VLD)

Dimensions

The Helicopter Main Blade Ballistic Test Facility is located on 1 acre of land between Ranges 6 and 7 adjacent to Phillips Air Field. A special test rig for stressing a 4- to 8-foot section of helicopter main rotor blade was designed and built for BRL by the Sikorsky Aircraft Division of United Aircraft Corporation. Installed in a 15- by 30-foot shelter of armor plate, the test rig can maintain up to 100,000 pounds of centrifugal load and 300,000 inch-pounds of bending moment on blade test sections before, during, and after test firings. An 8- by 20-foot trailer for personnel and instrumentation is shielded by 1/2-inch steel plates.

Weapons/Projectiles Available

A range of launcher sizes is available; up to 57-mm for powder charged launchers and up to 0.6 inch for light gas launchers. Projectiles may be fired from up to 50 feet from the test specimen.

Environment

This facility is an outdoor facility; therefore, only sea level ambient conditions can be obtained.

Live/Inert Fire

Fragmentation rounds can be fired if they conform to safety requirements for containment of fragments.

Safety (and Security) Requirements

Safety procedures for this facility are currently being generated and will be on file at the BRL Security Office. Arrangements can be made to handle classified material and weapons.

Power Availability

Up to 220 volt, 3-phase power can be provided to this facility through normal channels. Portable generators can be used to fill other types of power requirements.

Observation/Communication

Observation can be maintained from an instrumentation trailer or portable armor "bomb-proofs". Communication is also controlled from the trailer.

In-Flight Ballistic Instrumentation

TIMING. Electronic counters are used for paperbreak velocity measurements.

TELEMETRY. Paperbreak velocity measurement devices are used to obtain in-flight velocity measurements. Two devices are located approximately 5 feet apart midway between launcher and test rig.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Milliken cameras (400 frames/sec) and still photographs normally are used to record test results. High-speed motion cameras (32 and 64 frames/sec), Fastex cameras (100 to 1000 frames/sec) and chronographs are also available.

TIMING. Electronic counters may be used.

TELEMETRY. Strain gage measurements are normally obtained to verify centrifugal load and bending movement applied to test section.

EXPERIMENTAL EXPLOSIVE AREA (Range 12) (WMD)

Dimensions

The Experimental Explosive Area is located in the center of several acres. It consists of a steel explosion barricade and a two-stage light gas gun. The barrel-to-target distance is 19 feet. An instrumentation and control van is located approximately 200 feet from the firing site.

Weapons/Projectiles Available

The two-stage light gas gun can propel a 250-grain projectile at 9000 ft/sec. With a 40-grain fragment, velocities of 13,000 ft/sec are obtainable. It has interchangeable barrels for projectiles from .30 to .69 caliber. Fragments and projectiles can also be fired saboted. While targets several feet square can be used, the impact area is only 4 in^2. Targets may contain up to 10 pounds of HE.

Environment

Only ambient conditions of pressure and temperature are available.

Live/Inert Fire

Only inert projectiles are fired. However, targets may contain up to 10 pounds of HE.

Safety (and Security) Requirements

Classified materials and equipment can be accommodated at this range.

Power Availability

Standard 110-volt power is available.

Observation/Communication

No direct observation of tests is permitted.

In-Flight Ballistic Instrumentation

No in-flight ballistic instrumentation is used.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Two 150 kVA and two 300 kVA x-ray units can provide two sets of orthogonal photographs. High-speed photography normally is not used.

TIMING. Oscilloscopes and aluminum foil screens (make-circuits) are used to measure striking and residual velocities.

TELEMETRY. Strain gage technology is available.

Environmental Simulation and Measurement

No environmental simulation is performed at this facility.

LARGE CALIBER PENETRATION RANGE (TED)

Dimensions

The Large Caliber Penetration Range is an area of several acres with a large building housing photograph and machine shop support services (approximately 2000 yards from the firing site), and an instrumentation van, an armored observation shelter, and an armored instrumentation shelter at the firing site. Large caliber weapons are fired over distances of up to 200 meters at material, component, and aircraft targets of almost unlimited size. Targets may contain small amounts of HE or service type ordnance.

Weapons/Projectiles Available

Large caliber weapons from 20- through 152-mm are commonly fired at this range. Shaped charges and antiarmor missiles may also be fired. While smaller caliber weapon tests are normally done on smaller ranges, all weapons fired at the Penetration Range can be used on the Large Caliber Penetration Range if desired (e.g., due to target size).

Environment

Tests at this range are conducted outdoors at ambient atmospheric conditions. Target materials may be temperature conditioned using portable heating and cooling sources. No other environmental simulation is done.

Live/Inert Fire

Live fire may be done at this range.

Safety (and Security) Requirements

Range safety requirements are available upon request. Classified material or equipment can be stored at this facility.

Power Availability

Normal 110- and 220-volt, 3-phase, and 440-volt power is available at the range. Portable generators are available to satisfy additional requirements.

Observation/Communication

Tests may be observed through vision blocks in the observation shelter.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Still, high-speed motion, and streak cameras are available for use. Fastex cameras with frame rates up through 4000 frames/sec and Beckman Whitley streak cameras normally are used.

Up to nine Field Emission Corporation 150 kVA x-ray units may be used (normally in orthogonal pairs) for x-ray photographs.

TIMING. Chronographs (μsec accuracy) are used with paperbreaks or electronic light screens to measure projectile velocities.

HARDWIRE. Gun functions may be instrumented to measure pressure and strain. Measurements are recorded on oscilloscopes, strip chart records, oscillographs, or magnetic tape.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The photographic and x-ray instrumentation documented for in-flight ballistic instrumentation can be (and normally is) used for terminal ballistic instrumentation. The x-rays and cameras are used to record both before and behind the plate terminal effects.

TIMING. Chronographs are used with paperbreaks or electronic light screens to determine striking velocities.

HARDWIRE. Pressure, temperature and strain gage measurements may be recorded on oscilloscope, strip chart recorder, oscillograph or magnetic tape.

Environmental Simulation and Measurement

No environmental simulation is done at this facility other than temperature conditioning target materials.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The Computer Support Facility of the BRL has a large and diverse complement of equipment for processing data in either analog or digital form. Available computer facilities may be used to store data on either 7- or 9-track magnetic tape or on punched cards. The following equipment can be used to digitize charts, oscillographs, or film of various sizes:

1. Telereadex, Telecordex, Typewriter and IBM 523
   Gang Summary Punch
   Input: 16- or 35-mm negative, sprocketed, framed film
   Output: type tabulation and/or punched cards
   Magnification: 5X, 10X, 20X, 30X and 40X
   Counts/mm: 64, 130, 270, 405, and 620
   Output Digits: ±5 digits

2. Telereader 17c, Telecordex, Typewriter and IBM 523
   Input: negative or positive film and charts 16-mm to 12 inches wide by 100 feet
   Output: typed tabulation and/or punched cards
   Magnification: 2X, 4X, 11X
   Counts/mm: 15, 35, 85
   Output digits: ±16 digits

3. Chart Reader, Telecordex Typewriter and IBM 523
   Input: negative or positive film and charts up to 18 inches wide by 120 feet
   Output: typed tabulation and/or punched cards
   Magnification: none (direct viewing)
   Counts/mm: 15.59
   Output digits: ±6 digits

4. Bendix Datagrid Digitizer
   Input: film and charts up to 48 by 60 inches by any length
   Output: magnetic tape
   Magnification: none (direct viewing)
   Counts/in.: 1000
   Output digits: ±5 digits

Analog magnetic tape (1/2 or 1 inch) may be converted to digital magnetic tape using an Astordata Magnetic Tape Conversion Station.

QUICK-LOOK CAPABILITIES

There are no quick-look capabilities, as such, at this facility; however, black and white high-speed motion films, stills and flash x-rays can be processed within 30 minutes to an hour after a test is completed.

PROCESSING

System and Model

The primary digital computers are BRLESC I and II which are off-line supported by an IBM 1401 system and in-house developed data (converted card to tape, card to printer, tape to printer).

A large hybrid computer facility is also available. This system is an EAI 690 system comprised of one digital computer, EAI 640, and two analog computers, two EAI 680s.

Language

FORTRAN and FORAST can be used on both BRLESC I and II. The OMNITAB II programming system is available on BRLESC II.

FORTRAN and HOI (Hybrid Operations Interpreter) may be used on the EAI 690 system.

Input/Output Options

Input/output may be accomplished on the BRLESC I and II systems using card reader, card punch, printer or magnetic tape (7- or 9-track).

On the EAI 690 system, teletype, card reader, printer or 9-track magnetic tape may be used.

Realtime Interaction

No realtime interaction is available at this facility.

DISTRIBUTION

Turnaround time is highly dependent upon the amount of data required from a test. Black and white films could usually be processed within an hour after completion of the test. Color film processing could require up to a week.

ANNEX F - INTRODUCTION

OVERVIEW

That portion of the NSWC (Naval Surface Weapons Center) located at White Oak in Silver Spring, MD, was previously named the NOL (Naval Ordnance Laboratory) and is referred to by its old name in the following. NOL is located just outside the Washington, D. C., Beltway (Interstate 495) on New Hampshire Avenue (Route 650). The primary mission of the NOL is to conduct a program of warfare analysis, research, design, development, test, evaluation, systems integration, and fleet support principally in areas of surface and undersea warfare and to conduct investigations into related fields of science and technology. The particular technology areas that NOL supports are strategic systems, naval mine systems, multimedia weapons, directed energy weapons, fuze development, small craft armament, swimmer weapons systems, and ordnance technology. To accomplish this technical research, NOL has a variety of capabilities including supersonic, hypersonic, and hypervelocity wind tunnels, fuze test and evaluation facility, ballistic ranges, explosive testing facilities, explosive processing, hydroballistics tank, ordnance materiels laboratory, acoustic calibration facility, nuclear chemistry facility, degaussing model facility, weapons tank, mine test range, ordnance test ranges, acoustical range, vulnerability and hardness facility.

The majority of the ballistics and ordnance test range efforts are under either the Hydroballistics and Mechanics Division (Code 322), the Missile Dynamics Division (Code 323), or the Environmental Simulation Division (Code 702). The primary point of contact for use of these facilities is Dr. W. Carson Lyons, telephone 301-394-2318.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The NOL normally does not test aircraft systems or subsystems such as wings, fuselage, propulsion systems, or fuel cells. Instead, NOL tests against armor plate or other similar targets that simulate the item to be tested.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There are three indoor ballistic test facilities located at the NOL, two in-flight ballistic test facilities and a terminal ballistic facility. In addition, there is a shock test facility and a new explosion dynamics impact range. These facilities have instrumented ballistic ranges of from a few feet to 870 feet and vary from full environmental simulation capability to simple ambient air conditions. The three indoor ballistic test facilities have severe limitations with regard to the firing of explosive detonating rounds.

ACCESS

The primary access to the NOL is by highway, particularly Interstate 95 and Interstate 70. There is neither rail access to the facility nor air access nearby. Therefore, at least terminal routing by road would be required for any materials transported to NOL for testing.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capabilities at the NOL are similar to those at most laboratories. A wide variety of special purpose-type items can be fabricated; however, government-furnished maintenance for items in the inventory such as might be performed at an operational base normally is not conducted at NOL.

LOGISTICAL SUPPORT CAPABILITY

The location of the NOL away from normal military facilities makes the logistical support more difficult than might be expected at other ballistic test areas. All logistics items would have to be shipped in at least from a terminal port by road to NOL. Numerous ordnance storage bunkers (both above and underground) are located in the 300 acres of NOL. These facilities can easily be used for up to 6 months for any one test series.

INDOOR FACILITIES

1000-FOOT HYPERBALLISTICS RANGE (Code 323)

Dimensions

The Hyperballistics Range is 1000 feet long of which 870 feet is instrumented. Range diameter is 10 feet.

Weapons/Projectiles Available

A 2-inch, 480-caliber two-stage light gas gun can propel a 170-gram package downrange at 23,000 ft/sec, while 1000 grams can be accelerated to 20,000 ft/sec with a 4-inch barrel. Additional launchers (powder charged) as well as user-provided launchers can be accommodated.

Environment

The range can be evacuated to simulate high altitude flight. Test models can be preheated before launch. Rain and dust can be simulated.

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Live/Inert Fire

In general, only inert projectiles are fired. Small point-detonating projectiles can be used, but this would have to be coordinated carefully with the NOL prior to use.

Safety (and Security) Requirements

Classified materials and equipment can be accommodated. Central control coordinates all safety-related functions. No personnel are allowed to observe outside of central control during operations.

Power Availability

Because of the indoor and highly controlled nature of this facility, power availability for weapon usage is not a problem.

Observation/Communication

This item is not applicable for this facility.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The range is instrumented over 870 feet of its length. Drag measurements can be made over 785 feet, while stability can be measured over 340 feet.

PRESSURIZED BALLISTICS RANGE (Code 323)

Dimensions

The Pressurized Ballistics Range is 300 feet in length of which 154 feet is instrumented. Range diameter is 3 feet with the exception of a 20-foot section 5 feet in diameter.

Weapons/Projectiles Available

This facility can test up to 2-inch, 800-gram projectiles (to 3500 ft/sec). A maximum velocity of 21,000 ft/sec may be achieved using a 7-gram projectile. Two 2-stage, light gas launchers and 15 powder launchers are available for use. Both smooth and rifled barrels from 1/4 inch diameter to 4-inch diameter are available. User launchers may also be accommodated.

Environment

The Pressurized Ballistics Range can simulate atmospheric pressure from 0.5 mm Hg to 5 atmospheres.

Live/Inert Fire

Projectiles fired from gas guns are primarily inert. Small point-detonating projectiles can be used in this facility but this would have to be carefully negotiated with the NOL prior to use.

Safety (and Security) Requirements

Classified materials and equipment can be accommodated.

Power Availability

Because of the indoor and highly controlled nature of the Pressurized Ballistics Range, power availability for weapon usage is not a problem for this facility.

Observation/Communication

Because of the special nature of the Pressurized Ballistics Range, observation and communication is highly restricted with only post-flight data reduction and analysis available.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Spark shadowgraph stations (24), each producing two orthogonal views, are distributed along the 154 feet of this ballistic range. These shadowgraph stations can obtain extremely accurate (0.015 inch location and 0.1 degree orientation) data over a wide range of temperature and pressure. X-ray photographic stations can be positioned near gun muzzle for sabot studies.

TIMING. Timing is accomplished using electronic (accuracy 0.2 μsec) counters at each station. Gun functions are also timed using electronic counters.

TELEMETRY. There is no current capability for telemetry in this facility.

OTHER. Muzzle whip studies can be done using Hall gage (circuit/magnet) instrumentation on the 1.27-inch light gas gun. Acoustic measurements of shock wave phenomena can be made.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Two x-ray photographic stations, each producing two orthogonal views, may be positioned 5 feet apart to record impact data.

TIMING. Timing is accomplished with electronic counters (2 μsec accuracy).

TELEMETRY. Strain gage technology is available.

Environmental Simulation and Measurement

There is an extremely wide range of environmental simulation capabilities available in this indoor facility. For instance, the atmospheric pressure can be simulated from 0.0007 to 5 atmospheres. Foreign gas injection can reproduce a variety of different atmospheres.

Planned Expansion/Modification

No facility changes are currently planned at this time.

HYPERVELOCITY IMPACT RANGE 1 (Code 323)

Dimensions

The Hypervelocity Impact Range 1 is 25 feet long and 6 feet in diameter. The last 5 feet is the target area. Access port is 2 by 4 feet.

Weapons/Projectiles Available

Light, aerodynamic shapes less than 0.5 inch in diameter can be launched from 3000 to 20,000 ft/sec using a 2-stage light gas launcher. Other launchers can be accommodated.

Environment

The atmosphere in the test chamber can be varied from 0.2-mm Hg to 1 atmosphere.

Live/Inert Fire

No live projectiles may be fired.

Safety (and Security) Requirements

No personnel are allowed on the range during firing. Classified material and equipment would be difficult to handle.

Power Availability

The enclosed nature of this facility makes power availability not a problem.

Observation/Communication

No realtime observation is allowed.

In-Flight Ballistic Instrumentation

Only terminal ballistic instrumentation is available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. A Beckman Whitley 192 camera (framing rates to 5 μsec) with associated square wave light sources can record impact, spallation and residual energy data either before or behind the target impacted.

Two flash x-ray photograph stations (two orthogonal views) 5 feet apart provide projectile terminal ballistic data.

TIMING. Electronic counters provide timing data for the camera light screen actuated x-ray stations.

TELEMETRY. Strain gage type instrumentation is available.

Environmental Simulation and Measurement

The pressure in this range may be varied from 0.02-mm Hg to 1 atmosphere.

Planned Expansion/Modification

No modifications are currently planned at this time.

OUTDOOR FACILITIES

EXPLOSION DYNAMICS IMPACT FACILITY (Code 322/242)

Dimensions

The Explosion Dynamics Impact Facility is a bomb-proof enclosure with interior dimensions of 9 feet 6 inches by 7 feet 11 inches, 8 feet high. Access to the interior is through a porthole 33 inches by 8 feet.

Weapons/Projectiles Available

Shapes representing fragments or projectiles up to 20 mm size can be launched from 4000 to 8000 ft/sec using a 2-stage gas launcher. Projectiles strike targets of up to 1.5 pounds of explosive.

Environment

Tests are run at ambient atmospheric conditions only.

Live/Inert Fire

Either live or inert projectiles may be fired. Targets may contain up to 1.5 pounds of explosive.

Safety (and Security) Requirements

The facility is cleared before test firings. The facility has capability for storing classified material or equipment.

Power Availability

Only 110- and 220-volt power is available.

Observation/Communication

There are no facilities for realtime observation of tests.

In-Flight Ballistic Instrumentation

Only terminal ballistic instrumentation is available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photographs are taken through a viewport using a Dynaflex camera (25,000 frames/sec) of the terminal flight and explosive interaction. An expendable light source provides 3 msec of illumination. A 300 kV flash x-ray with two heads is available for certain applications.

TIMING. Timing information is derived from the photographic frame rate.

TELEMETRY. Strain gage technology is available.

Facility Expansion/Modification

Improved photography using a Super Dynaflex camera (100,000 frames/sec) is planned.

AIR LAUNCHED SHOCK TEST FACILITY (Code 702)

Dimensions

This outdoor facility has a projectile free-flight range of only a few feet after it emerges from either the 20- or 22-foot launcher. There are no restrictions on lateral travel due to the short distances involved.

Weapons/Projectiles Available

Launcher barrel diameters of 2.25, 3.00, and 5.00 inches can accommodate a wide variety of either inert or explosively loaded projectiles. Either wooden sabots or nylon sleeves normally are used to adapt the projectiles to the existing barrels. The use of customer-provided guns is not consistent with the concept of the facility.

Environment

The terminal, free-flight portion of the facility is outside and subject to ambient conditions.

Live/Inert Fire

Both live and inert fire projectiles can be accommodated in the facility.

Safety (and Security) Requirements

Visual safety interlocking with a deadman switch is the primary safety mechanism. No realtime observation is allowed.

Power Availability

Only 3-phase, 110-volt power normally is available. Generators/converters could be made available as needed.

Observation/Communication

Both observation and communication are limited due to safety and facility configuration.

In-Flight Ballistic Instrumentation

All instrumentation is oriented to the terminal ballistics including impact, detonation and fragmentation.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed movie cameras provide projectile flight and impact.

TIMING. Camera frames rate plus counters for gun/launcher functions provide the majority of the timing.

TELEMETRY. The air launcher is thoroughly instrumented so that all launcher functions can be accurately obtained. This includes both peak and continuous projectile acceleration (800 to 3900 *g*'s) as well as a muzzle velocity (500 to 1200 ft/sec).

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The majority of data collected at these facilities are in the form of photographs (optical, laser, x-ray, or shadowgraph). All data are manually read from the

photographs and keypunched on computer cards. Since computer facilities are available, the data could be stored on disc or magnetic tape. Timing data are recorded from digital counters and are keypunched also.

QUICK-LOOK CAPABILITIES

Photographs are available from 10 minutes to 1 day after the test. Data reduction from photographs would require approximately 1 day after receipt of the photographs (this is highly dependent upon the length of the test, instrumentation configuration and amount of data to be extracted from the photographs).

PROCESSING

System and Model

The NOL Computer and Data Processing Facility operates a computer facility equipped with a CDC-6500 computer system (138K core) with one 6638 disc system supporting four 854 disc storage drives and three 841-4 multiple disc drives.

Language

The following languages may be used at this facility:

1. COMPASS (assembly language)
2. FORTRAN
3. SNOBOL
4. SIMSCRIPT
5. COBOL
6. BASIC.

Input/Output Options

Input/output may be accomplished with the following facilities:

1. Card reader
2. Card punch
3. Line printer
4. Magnetic tape (8-7 track and 1-9 track)
5. Gould Electrostatic Plotter.

Realtime/Interaction

A time-sharing system with 64 remote teletype or teletype-like terminals, three CRT displays, a CDC-243-1 GRID Graphics terminal, and three remote batch terminals is available for use.

DISTRIBUTION

Turnaround time is highly dependent upon the amount of data required for a test. Data requirements could probably be fulfilled within 1 working day after a test.

DISPLAYS

One 243-1 GRID Graphics terminal and three remote CRT displays are available for CDC-6500 computer facilities. High-speed camera films can be projected.

ANNEX G - INTRODUCTION

Overview

That portion of the NSWC (Naval Surface Weapons Center) known as the DL (Dahlgren Laboratory) located at Dahlgren, VA, and was previously named NWL (Naval Weapons Laboratory). DL is located in Dahlgren, VA, just off U.S. Highway 301 and the Potomac River. The station contains approximately 4400 acres of land on which are located firing sites, test areas, support shops, an airfield and office buildings. In addition, DL has an instrumented water range over the Potomac River of approximately 25 miles in length and 5 miles in width.

The DL assigned mission is to conduct a comprehensive program of warfare analysis, research, development, test evaluation, system integration and fleet engineering support for surface warfare and related fields of technology. DL has been the Navy's main shore-based ordnance materials test organization since its inception in 1918.

The primary point of contact for use of Dahlgren's facilities is Mr. Jack Loving, telephone 703-663-7468.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The full gamut of aircraft vulnerability gun ballistic testing is available at DL from armor plate through aircraft structures, aircraft propulsion systems and total aircraft testing. Antiaircraft programs constitute a major program effort within DL's mission.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Six major facilities or ranges make up the majority of the DL aircraft oriented ballistic test capability. These facilities are:

1. Machine Gun Range
2. Main Range
3. Antiaircraft Fuze Range
4. Missile Test Facility
5. Terminal Range
6. Explosive Experimental Area.

None of these ranges are totally contained as indoor ranges. However, there are individual parts of each range that are either wholly or partially indoors. Live explosives can be handled on all ranges.

ACCESS

The DL has a multitude of access opportunities. The primary access is U.S. Highway 301 running from Baltimore, MD, to Richmond, VA. In addition, there is a 4000-foot runway on the station for the landing of military aircraft. Air freight normally is handled through National Airport in Washington, D.C., and transported to DL. Items which exceed highway limitations may be delivered via the Chesapeake Bay and the Potomac River on barges. A railroad is available on the station, but there is no access to outside commercial rail facilities.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capabilities of DL are extensive. They range from the normal one-of-a-kind type laboratory fabrication capability up through and including standard maintenance on operational items required for initial or follow-on operational test and evaluation.

LOGISTICAL SUPPORT CAPABILITY

Since the DL provides in-service engineering to the Fleet and acceptance testing for gun and rocket systems, the logistical support capability for weapons and ammunition is extensive. Complete facilities for explosives handling, assembling, dis-assembling, and fuzing are in close proximity to all firing ranges. Logistical support for aircraft systems and components can be provided by the nearby Naval Air Test Center, Patuxent, MD.

INDOOR FACILITIES

MACHINE GUN RANGE

Dimensions

The Machine Gun Range consists of five completely enclosed firing bays, four partially enclosed firing bays, and one open firing range. The partially indoor facility can handle up to 3-inch-diameter weapons, including 57-mm antiaircraft guns. The light armor range has recently been included under the Machine Gun Range complex. The indoor bays are restricted from firing anything larger than 30-mm due to the inability to retain the round in the sand butts. Of the five indoor firing ranges, three are 100 feet long and terminate in sand-filled bulkheads. One bay has been lengthened to 200 feet and large access doors installed to permit locating aircraft fuselage sections in the bay for bullet impact tests. The remaining bay, which is used for light armor evaluation, has target positions from 30 to 160 feet and terminates in an STS steel explosive chamber. The indoor firing ranges are all approximately 15 feet wide by 15 feet high. On the open and partially enclosed ranges, projectiles can be fired out onto the river range either at barge mounted targets or

remotely controlled pilotless aircraft targets. One of these ranges has a gun emplacement in a temperature conditioning bay that permits firing of the weapons at extreme temperatures.

Weapons/Projectiles Available

Gun systems of 3 inches or less can be tested in the Machine Gun Range facilities. Large caliber guns have been fired on the open ranges under special circumstances. Projectiles as large as 5 inch have been fired for water impact from the emplacement in the temperature conditioning bay. Projectiles fired on the indoor ranges are limited to 30-mm or smaller. Targets of armor plates and special test sections can be accommodated on all ranges. The light armor range has an armor pendulum to allow positioning of the armor plate at various angles of obliquity to both the horizontal and the vertical. In addition to these capabilities, live warheads may be used for targets with approval of the Safety Officer.

Special barrels are available to provide controlled yaw of projectiles for impact in aircraft components.

Environment

Temperature conditioning chambers may be used to condition guns, explosives, or inert items to temperature extremes ranging from +200° to -65°F. Temperatures may be controlled in the temperature conditioning firing bay from -70° to +140°F.

Live/Inert Fire

Live fire can be accommodated on all bays of the Machine Gun Range up to the projectile size limits stated. Safety regulations for this area prohibit detonating more than 10 pounds of HE.

Safety (and Security) Requirements

Standard safety procedures are followed for all indoor facility tests at the Machine Gun Range. In addition, there is a firing switch interlock at the firing control center for each of the weapon bays.

Classified weapons, ammunition, and equipment can be accommodated at this range.

Power Availability

All types of normal weapon power are available at the Machine Gun Range, varying from 110 to 440 VAC single and 3-phase, 60- and 400-cycle and 28 VDC, the latter being critical for aircraft gun development testing.

Observation/Communication

Machine gun tests can be observed only from behind the firing bay. Limited CCTV (closed circuit television) is used in some indoor and outdoor operations. An extensive communication system is used by the Machine Gun Range facility in order to coordinate all facility testing. A multichannel, land line/VHF FM communications system provides reliable voice communications to/from all firing bridges, range control office, range boats, range stations, and instrumentation facilities.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A wide range of photographic capability exists at DL, ranging from 8 by 10 still cameras up through ultra-high speed motion picture cameras with frame rates up to 2.5 million frames/sec. Motion picture film sizes of 8, 16, 35, and 70 mm are available. Sequence cameras, streak cameras (with equivalent writing speeds up to 6000 frames/sec), ballistic synchro cameras, and other special purpose cameras are available. A Model 1D Image Converter Camera, capable of functioning as a framing, streak, or strobe, provides the capability to record time-resolved spatial and intensity data for a wide variety of luminous transient data.

TIMING. Time code generators broadcast IRIG-B timing signals and other timing devices are extensively used within the Machine Gun Range due to the requirement to obtain highly accurate gun functioning time parameters during the early stages of gun development. Velocity data, keyed to time code generators, are recorded on 14 tape channels, high-speed printers, and oscillograph recorders.

TELEMETRY. The Machine Gun Range uses hardwire instrumentation to measure and record gun function parameters and projectile muzzle velocities. Pressure, force, acceleration, velocity, displacement, temperature, and strain are frequent requirements. Normally 14 tape channels are used for the majority of the testing; however, 32 tape channels can be provided under special conditions. A projectile velocity determining system has the capability of realtime printout and recording of individual round velocities leaving the barrel at rates of fire of up to 6000 rounds/min. The closed firing bays normally have velocity data terminals 80 feet from a gun emplacement. Photoelectric screens and magnetic rings are the primary sources of velocity information.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. All cameras used for in-flight instrumentation also can be used for terminal ballistic instrumentation.

Flash radiography can be provided by mobile units. Either 300 or 600 kV units are available. CCTV can also be used in either the indoor or the outdoor bays.

TIMING. Timing information is provided by high-speed cameras and chronographs with various triggering devices.

TELEMETRY. Thermocouple, strain gage, and other target parameter measurements can be hardwired to the range instrumentation center and recorded on magnetic tape or oscillograph.

Environmental Simulation and Measurement

Extensive temperature conditioning facilities are available at the Machine Gun Range. Several heating and cooling ovens are available throughout the range area. There are two temperature conditioned firing bays that fire onto the river range. A temperature conditioning room is 25 by 30 by 24 feet and contains a gun emplacement which can be used to fire down the river range. The temperature can be controlled between -70° and +140°F. Additional conditioning chambers totaling a volume of 12,500 ft^3 feet can be used to temperature condition both explosive and inert items over a range of -65° to +160°F.

Special conditioning enclosures can be fabricated to meet special requirements. Portable heating and cooling sources are available for use if required.

OUTDOOR FACILITIES

MAIN RANGE

Dimensions

The Main Range is located adjacent to the Potomac River. The gun line is located to form continuous ranges that average 1200 feet of land range and approximately 25 miles of water range with an average width of 5 miles. Air space above the range is restricted to ensure that aircraft traffic is not permitted over the range during tests. Firing is controlled from four individual test stations.

Weapons/Projectiles Available

Gun emplacements suitable for firing all types of Naval guns up to and including 16-inch guns are located at this complex. At least one gun of each type currently in use by the Fleet is available for test and evaluation of conventional ordnance components and for research and development of new weapons systems. Targets can be located as far away as 1100 feet at the river's edge and on barges further out in the river. An AMMI platform, 104 feet by 40 feet and maintained on steel pilings 5 feet above the water surface, is located 9400 yards from the Main Range gun line. The AMMI serves as a stable platform for various type targets and for launching rocket propelled target vehicles toward the gun line for gun fire intercept.

Environment

Conditioning cabinets for conditioning ammunition and related components are available for temperature ranges from -100° to +500°F. Some of these cabinets have humidity control. Firing emplacements are in the open.

Live/Inert Fire

Live fire may be employed on this range, up to and including 16-inch caliber.

Safety (and Security) Requirements

Firing from the Main Range is controlled from four individual locations. Visual and radar surveillance of all ranges is constantly maintained during firing programs. Firing train angle is limited to from 5 to 15 degrees, depending on predicted maximum range and whether the projectile is live or inert.

Classified weapons, ammunition, and equipment can be accommodated at this range.

Power Availability

110, 220, and 440 VAC power (single-phase, 3-phase, 60 and 400 cycle) are available at all sites of the Main Range. 110 VDC power is also available.

Observation/Communication

Direct observation of firings is not only possible, but mandatory as part of the safety requirement of this range. A multichannel, land line/VHF FM communications system provides reliable voice communications to/from all firing bridges, range control office, range boats, range stations, and instrumentation facilities. VHF and UHF AM transceive capability is included at Range Control for ground-to-air communication.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A wide range of photographic capability exists at DL, ranging from 8 by 10 still cameras up through ultra-high speed motion picture cameras with frame rates up to 2.5 million frames/sec. Motion picture film sizes of 8, 16, 35, and 70 mm are available. Sequence cameras, streak cameras (with equivalent writing speeds up to 6000 frames/sec), ballistic synchro cameras, and other special purpose cameras are available. A Model 1D Image Converter Camera, capable of functioning as a framing, streak, or strobe camera, provides the capability to record time-resolved spatial and intensity data for a wide variety of luminous transient data.

TIMING. IRIG-B timing is generated at a central location and is received at all major instrumentation and photographic sites. Timing sequential counters and special counters are available for timing of gun function events. Velocity ring counters are also available, as well as radio doppler velocimeters which provide velocity versus time data.

TELEMETRY. For hardwired systems, the capability exists for the measurement of any parameter normally associated with gun firing. Pressure, force, acceleration, velocity, displacement, temperature, and strain are frequent requirements. Signal

conditioning for all data requiring a data response to 2 kHz can be performed at the test site, converted to a FM/FM multiplex (24 channel capability), and connected via a single coaxial cable to the recording facility. Remote calibration is performed using a VHF/FM "touch tone" system.

Discrete cabling is employed between test site and instrumentation facility for multichannel high frequency data requirements. All data are recorded on analog tape (IRIG WB1) with strip chart and oscillographic reproduction or digitizing available.

Two Telemetry Ground Stations are in operation at the Dahlgren Range. One station is located behind the gun line at Main Range employing fixed "fan beam" antennas affording complete range coverage to 20,000 yards, with a vertical beamwidth of 40 degrees. The second system is contained in an 8 by 8 by 10 foot "Sea Van" and is configured for portable operation. This portable system is intended for downrange operation increasing the Dahlgren telemetry range capability to 30,000 yards. It is also ideally suited to shipboard installation, and temporary usage on other ranges. A NATO version of the PUTTS antenna tracking system is included in this system providing reliable antenna tracking of telemetry augmented missiles and projectiles.

Telemetry frequencies within the 1435 to 1540 MHz band and 2200 to 2300 MHz band can be received by both systems. Minimum antenna gain is 15 dBi. Demodulation capabilities exist for all IRIG 7 1/2% PBW channels, and CBW "B" channels. PAM/PDM decommutation systems are available. All data are recorded on analog tape with oscillographic and strip chart reproduction and digitizing available.

A portable receiving system for RF fuze testing has recently been established on the Dahlgren Range. A dual receive concept is utilized, one in the form of an electrically swept receiver, continuously scanning the spectrum of interest, and providing panoramic display of same. The second receiver is employed as a data receiver with selectable IF bandwidth and demodulations for intelligence extraction. The data receiver is slaved to the swept receiver. Frequency coverage to 1 GHz is currently available with expansion capability to 18 GHz. A 4 channel instrumentation tape recorder is included with this system.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Most Main Range firings terminate in the Potomac River with optical theodolite stations for determining the point of water impact. When the firing terminates on land, cameras used for in-flight ballistic instrumentation may also be used to record terminal effects. A 3-channel, 300-kV pulse x-ray system permits radiographic studies of explosive phenomena obscured from optical view. Auxiliary equipment such as counter chronograph and high-speed cameras permit determination of fragment velocity and patterns.

TIMING. Velocity coils are used for calculation of terminal velocities.

TELEMETRY. Terminal ballistic data are obtained on hardwired instrumentation for close land targets and can be collected from a number of range stations located along the entire water range on the Virginia and Maryland shores.

ANTIAIRCRAFT FUZE RANGE

Dimensions

The Antiaircraft Fuze Range is located in front of and to the southeast of the Main Range. Its length consists of approximately 200 feet of land range and the Potomac River water range. There are 12 gun emplacements located on the range. Eleven of the firing sites are used for guns and rocket launchers. The remaining site contains the NOMAD (Naval Ordnance Mass Acceleration Device), a centrifuge used to test missile firings under load.

Weapons/Projectiles Available

Projectiles and rockets up to 8 inches in diameter can be accommodated at this range.

The NOMAD centrifuge may be used to hold targets under simulated loads of up to 30 times normal gravity at 20-foot radius. Armor targets mounted on the centrifuge can be impacted at speeds up to 160 ft/sec to simulate in-flight conditions.

Environment

Six temperature conditioning rooms give the Antiaircraft Fuze Range the ability to bring projectiles, projectile propellant charges, and missile motors to temperatures ranging from -110° to +200°F. Total volume of those temperature conditioning rooms is more than 13,000 ft^3.

Live/Inert Fire

This range can accommodate live fire up to and including 8-inch guns and rockets. Fragmenting munitions are normally used.

Safety (and Security) Requirements

Blast shields and heavy steel baffles provide safety protection for this facility. There are also protected outside work areas and enclosed walkways between buildings.

Classified weapons, ammunition and equipment can be accommodated at this range.

Power Availability

110, 220, and 440 VAC, single and 3-phase, 60 and 400 cycle are available at this range. In addition, power generating equipment is available to supplement existing power at the firing site.

Observation/Communication

No close direct observation of the target is permitted; however, CCTV is available for remote viewing.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A wide range of photographic capability exists at DL, ranging from 8 by 10 still cameras up through ultra-high speed motion picture cameras with frame rates up to 2.5 million frames/sec. Motion picture film sizes of 8, 16, 35, and 70 mm are available. Sequence cameras, streak cameras (with equivalent writing speeds up to 6000 frames/sec), ballistic synchro cameras, and other special purpose cameras are available. A Model 1D Image Converter Camera, capable of functioning as a framing, streak, or strobe camera, provides the capability to record time-resolved spatial and intensity data for a wide variety of luminous transient data.

TIMING. IRIG-B timing is available. Timing sequential counters and special counters are available for timing of gun function events as well as detonation events. Velocity ring counters are available, as well as radio doppler velocimeters.

TELEMETRY. For hardwired systems the capability exists for the measurement of any parameter normally associated with gun firing. Pressure, force, acceleration, velocity, displacement, temperature, and strain are frequent requirements. Signal conditioning for all data requiring a data response to 2 kHz can be performed at the test site, converted to a FM/FM multiplex (24 channel capability), and connected via a single coaxial cable to the recording facility. Remote calibration is performed using a VHF/FM "touch tone" system.

Discrete cabling is employed between test site and instrumentation facility for multichannel high frequency data requirements. All data are recorded on analog tape (IRIG WB1) with strip chart and oscillographic reproduction of digitizing available.

A portable receiving system for RF fuze testing has recently been established on the Dahlgren Range. A dual receive concept is utilized, one in the form of an electrically swept receiver, continuously scanning the spectrum of interest, and providing panoramic display of same. The second receiver is employed as a data receiver with selectable IF bandwidth and demodulations for intelligence extraction. The data receiver is slaved to the swept receiver. Frequency coverage to 1 GHz is currently available with expansion capability to 18 GHz. A 4 channel instrumentation tape recorder is included with this system.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The same photographic capabilities available for in-flight ballistic instrumentation are also available for recording terminal effects.

TIMING. IRIG-B timing is available. Velocity coils are used for calculation of terminal velocity.

TELEMETRY. Terminal ballistic information is obtained by hardwired instrumentation or photography for close land targets and from a number of range stations located along the entire water range on the Virginia and Maryland shores for observing and recording terminal ballistic events on the water range.

MISSILE TEST FACILITY

Dimensions

The Missile Test Facility range is adjacent to the water range and is surrounded on three sides by a large amount of open area. There is approximately 1000 yards of land range and the water range also may be utilized when desired.

Weapons/Projectiles Available

The Missile Test Facility is primarily used for testing rockets of up to 3 feet in diameter and 2000 pounds. Additionally, however, small-to-medium caliber projectiles may be fired on this range. Rocket sleds are also available to propel components to impacts with antiaircraft shells to simulate mid-air high-speed encounters. Test item velocities of 1500 ft/sec can be obtained.

Environment

Open air ambient conditions are the only conditions available at this outdoor facility.

Live/Inert Fire

The Missile Test Facility can accommodate live fire up to an equivalent of 100 pounds HE. Fragmenting munitions may be used on this range.

Safety (and Security) Requirements

Persons working at the Missile Test Facility are required to be familiar with the many special purpose shelters and the safety regulations governing their use. The facility office, ammunition preparation rooms, and ambient storage magazines are located in a bomb-proof building underneath the fire control bridge. A facility lookout and firing director supervise all tests.

Classified weapons, ammunition and equipment can be accommodated at this range.

Power Availability

Power generating equipment can supply any power required for tests. 110 and 220 VAC single-phase; 60 Hz permanently installed.

Observation/Communication

Tests may be observed through safety glass windows, CCTV, or an optical periscope. A multichannel, land line/VHF FM communications system provides reliable voice communications to/from all firing bridges, range control office, range boats, range stations, and instrumentation facilities.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A wide range of photographic capability exists at DL, ranging from 8 by 10 still cameras up through ultra-high speed motion picture cameras with frame rates up to 2.5 million frames/sec. Motion picture film sizes of 8, 16, 35, and 70 mm are available. Sequence cameras, streak cameras (with equivalent writing speeds up to 6000 frames/sec), ballistic synchro cameras, and other special purpose cameras are available. A Model 1D Image Converter Camera, capable of functioning as a framing, streak, or strobe camera, provides the capability to record time-resolved spatial and intensity data for a wide variety of luminous transient data.

TIMING. IRIG-B timing is available. Additional timing capability can be provided by higher resolution time code generators, chronographs, and camera framing rates.

TELEMETRY. For hardwired systems the capability exists for the measurement of any parameter normally associated with gun or rocket firings. Pressure, force, acceleration, velocity, displacement, temperature, and strain are frequent requirements. Signal conditioning for all data requiring a data response to 2 kHz can be performed at the test site, converted to a FM/FM multiplex (24 channel capability), and connected via a single coaxial cable to the recording facility. Remote calibration is performed using a VHF/FM "touch tone" system.

Discrete cabling is employed between test site and instrumentation facility for multichannel high frequency data requirements. All data are recorded on analog tape (IRIG WB1) with strip chart and oscillographic reproduction or digitizing available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The same photographic capabilities available for in-flight ballistic instrumentation are also available to record terminal events. In addition, mobile radiography units can provide 300 and 600 kV x-ray capability.

TIMING. Terminal ballistic timing is generally accomplished by photographic means with IRIG-B signatures.

TELEMETRY. Terminal ballistic information is obtained from hardwired instrumentation.

OTHER. Armor plates or other targets may be supported at obliquities from 0 to 75 degrees with a pendulum-type target holder.

TERMINAL RANGE

Dimensions

The Terminal Range is approximately 1 mile from any other major facility. The total length of the facility is 1000 feet and it is bordered by the Potomac River water range. There are a total of 10 firing sites at the range. At nine of these sites the armor may be positioned at varying degrees of obliquity. Seven of the firing sites have fixed gun-to-butt distances from 15 feet to 200 yards. At all the firing sites the ability exists to fire into specially constructed boxcars filled with sawdust for the recovery of projectiles.

Weapons/Projectiles Available

The Terminal Range can accommodate projectiles up to 24 inches in diameter and 5000 pounds. Currently on the firing line are 3- to 16-inch rifled guns, 3- to 24-inch smooth bore guns, and a 4-inch light gas gun capable of firing projectiles of up to 2-1/2 pounds at 10,000 ft/sec. The light gas gun commonly fires sabot rounds.

Environment

Open air ambient atmospheric conditions are the only target conditions available at this outdoor facility. All rounds can be conditioned to any temperature level prior to firing.

Live/Inert Fire

Both live and inert fire can be accommodated by this facility. Large fragmenting munitions may be used with normal safety conditions observed.

Safety (and Security) Requirements

During tests it is necessary for all personnel to take shelter in authorized bomb-proof shelters. The firing control bridge, in addition to being a personnel shelter has facilities for storage and office space.

Classified weapons, ammunition, and equipment can be accommodated at this range.

Power Availability

110 and 220 VAC and 110 VDC power is available at the range. In addition, power generating equipment is available to supplement power at the firing sites.

Observation/Communication

No close direct observation of the target is permitted; however, optical periscopes and CCTV are available. A multichannel land line/VHF FM communications system provides reliable voice communication to/from all firing bridges, range control office, range boats, range stations, and instrumentation facilities.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A wide range of photographic capability exists at DL, ranging from 8 by 10 still cameras up through ultra-high speed motion picture cameras with frame rates up to 2.5 million frames/sec. Motion picture film sizes of 8, 16, 35, and 70 mm are available. Sequence cameras, streak cameras (with equivalent writing speeds up to 6000 frames/sec), ballistic synchro cameras, and other special purpose cameras are available. A Model 1D Image Converter Camera, capable of functioning as a framing, streak, or strobe camera, provides the capability to record time-resolved spatial and intensity data for a wide variety of luminous transient data.

TIMING. IRIG-B timing is available. Additional timing capability is provided by camera framing rates, chronographs, and when required, higher resolution time code generators.

TELEMETRY. For hardwired systems the capability exists for the measurement of any parameter normally associated with gun firing. Pressure, force, acceleration, velocity, displacement, temperature, and strain are frequent requirements. Signal conditioning for all data requiring a data response to 2 kHz can be performed at the test site, converted to a FM/FM multiplex (24 channel capability), and connected via a single coaxial cable to the recording facility. Remote calibration is performed using a VHF/FM "*touch tone*" system.

Discrete cabling is employed between test site and instrumentation facility for multichannel high frequency data requriements. All data are recorded on analog tape (IRIG WB1) with strip chart and oscillographic reproduction or digitizing available.

Two Telemetry Ground Stations are in operation at the Dahlgren Range. One station is located behind the gun line at Main Range employing fixed "fan beam" antennas affording complete range coverage to 20,000 yards, with a vertical beamwidth of 40 degrees. The second system is contained in a 8- by 8- by 10-foot "Sea Van" and is configured for portable operation. This portable system is intended for downrange operation increasing the Dahlgren telemetry range capability to 30,000 yards. It is also ideally suited to shipboard installation and temporary usage of other ranges. A NATO version of the PUTTS antenna tracking system is included in this system providing reliable antenna tracking of telemetry augmented missiles and projectiles.

Telemetry frequencies within the 1435 to 1540 MHz band and 2200 to 2300 MHz band can be received by both stations. Minimum antenna gain in 15 dBi. Demodulation capabilities exist for all IRIG 7 1/2% PBW channels, and CBW "B" channels. PAM/PDM decommutation systems are available. All data are recorded on analog tape with oscillographic and strip chart reproduction and digitizing available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The same photographic capabilities available for in-flight ballistics are also available for terminal ballistics. In addition, mobile radiography units can provide 300 and 600 kV x-ray capabilities.

TIMING. Velocity coils and high-speed photography may be used for terminal ballistic timing. IRIG-B timing is available.

TELEMETRY. Terminal ballistic information is obtained with hardwired instrumentation.

EXPLOSIVE EXPERIMENTAL AREA

Dimensions

The Explosive Experimental Area is a 1640-acre range separated from the main DL grounds by Upper Machodoc Creek. Major test facilities located in the area include surveyed static detonation arena sites varying in size up to 90 feet in radius, drop test towers, static thrust stands, thermal test retaining cages, slow cook-off facility, fast cook-off facility, shock test facility and HE vibration facility.

Weapons/Projectiles Available

The Explosive Experimental Area is used to conduct environmental and safety tests of explosive ordnance and rocket motors. The surveyed arena sites are used to determine terminal effects characteristics of warheads, bombs, and projectiles. Vulnerability tests with devices containing large quantities of explosives can be conducted in these arenas.

Environment

Open air ambient conditions are the only conditions available at this outdoor facility.

Live/Inert Fire

Rocket motors with up to 50,000 pounds thrust and explosive ordnance with up to 1000 pounds of HE or 2000 pounds of propellant can be safely handled and tested in the Explosive Experimental Area.

Safety (and Security) Requirements

Persons working in the Explosive Experimental Area are required to be familiar with the many special purpose shelters and the safety regulations governing their use. There are three control centers constructed of armor plate to house personnel, monitoring equipment, and data acquisition instrumentation. From these centers the major test areas may be viewed with periscopes, CCTV, or an arrangement of mirrors. The facility office and ambient ready service magazines are located in a

bomb-proof building. Barricades are used to isolate various test sites. A firing director and a facility look-out supervise all tests.

Classified weapons, ammunition, and equipment can be accommodated on this range.

Power Availability

110, 220, and 440 VAC, single- and 3-phase, 60 cycle are available at this range. In addition, power generating equipment is available to supplement existing power at the test sites.

Observation/Communication

Tests are observed by CCTV, optical periscopes, safety glass windows and mirrors.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A wide range of photographic capability exists at DL, ranging from 8 by 10 still cameras up through ultra-high speed motion picture cameras with frame rates up to 2.0 million frames/sec. Motion picture film sizes of 8, 16, 35, and 70 mm are available. Sequence cameras, streak cameras (with equivalent writing speeds up to 6000 frames/sec), ballistic synchro cameras, and other special purpose cameras are available. A Model 1D Image Converter Camera, capable of functioning as a framing, streak, or strobe camera, provides the capability to record time-resolved spatial and intensity data for a wide variety of luminous transient data.

TIMING. IRIG-B timing is available. Additional timing capability is provided by camera framing rates, chronographs, and when required, higher resolution time code generators.

TELEMETRY. The instrumentation system of the Explosive Experimental Area is capable of measuring such parameters as blast, temperature, pressure, velocity, shock, vibration, strain, acceleration, time and circuit constants. More than 80 kHz FM channels are available to record these parameters.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The same photographic capabilities available for in-flight ballistics are also available for terminal ballistics. In addition, mobile radiography units can provide 300 and 600 kV x-ray capabilities.

TIMING. Velocity screens and high-speed photography may be used for terminal ballistic timing.

TELEMETRY. Terminal ballistic information is obtained with hardwired instrumentation.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The majority of data collected at these facilities is in the form of photographs (optical, laser, x-ray, or shadowgraph) and magnetic tape recordings of hardwired gun and target functions. All data read from photographs can be keypunched on computer cards. Since computer facilities are available, the data could be stored on disc or magnetic tape.

QUICK-LOOK CAPABILITIES

Photographs are available from a few minutes after a test for x-ray and black and white film to as much as 4 days later for a color film. Oscillograms of most hardwired functions can be viewed near realtime.

PROCESSING

System and Model

Computer and data processing services are provided by a CDC-6700 system with three CPUs (CYBER 74, CDC-1774, and CDC-6713) and three EAI 680s equipped for realtime input of data through an optical link to the radar system on the Potomac River.

Language

The following languages may be used at this facility.

1. COMPASS (assembly language)
2. FORTRAN
3. SNOBOL
4. SIMSCRIPT
5. COBOL
6. BASIC
7. ALGOL

Input/Output Options

Input/output may be accomplished with the following facilities:

1. Card reader
2. Card punch
3. Line printer

4. Magnetic tape
5. Gould Electrostatic 480 Plotter
6. Paper tape reader
7. Calcomp 718 Flatbed Plotter
8. Stromberg-Datagraphics 4060 (Microfilm Plotter).

Realtime/Interaction

A time-sharing system with 40 remote teletype or teletype with CRT display terminals, and two 274 Graphics terminals are available for use.

DISTRIBUTION

Turnaround time is highly dependent upon the amount of data required for a test. Data requirements could probably be fulfilled within 1 working day after a test.

ANNEX H - INTRODUCTION

OVERVIEW

The NWC (Naval Weapons Center) located in China Lake, CA, is an activity of the NMC (Naval Material Command). The NWC employs about 4000 civilians and 1000 military personnel.

The mission of NWC is to "conduct a program of warfare analysis, research, development, test, evaluation, systems integration, and Fleet engineering support in Naval weapons systems and to conduct investigations into related fields of science and technology."

The NWC has developed such highly successful weapons as the Sidewinder, 2.75-inch rocket, Zuni, ASROC, Shrike, and Walleye.

The entire Randsburg Wash/Mojave "B" area and about 90% of the China Lake area are used for tests and evalutions. Most of the heavily instrumented test facilities are concentrated on or about the vast dry bed of a former Pleistocene lake which covers the southwestern quarter of the China Lake area.

The bed of the dry lake is flat and bare, ideally suited to the delivery of air- or ground-launched ordnance, and large enough to accommodate several aircraft-target ranges and missile impact zones. An 11,000-acre air base, missile and drone launching facilities, several high-speed test tracks, and the test control and support complex are located on the southern edge of the lakebed.

The NWC test complex contains 30 major facilities open to use by outside agencies and contractors. About one-third of the facilities are multiple-purpose test ranges for air or surface weapon systems and their major components. Three of the facilities are supersonic or transonic test tracks and the remainder are for test and evaluation of the propellants, explosives, fuzes, small-caliber guns and ammunition, electro-optical devices, electronic warfare, material vulnerability, and other specialized applications. The primary point of contact for this facility is the Branch Head, Survivability and Lethality Test Facility, Code 3184, (AV) 245-6201.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The NWC Aircraft Survivability Program is a long-range RDT&E (Research and Development, Test and Evaluation) program to improve the combat survivability of fighter, attack, and helicopter aircraft, both present and future models. Aircraft survivability RDT&E and S/V (survivability/vulnerability) analysis efforts are being conducted under a continuing program. NWC has design analytical and experimental capabilities in the following areas:

1. Development of survivability technology
2. Survivability design and system survivability application
3. S/V analysis
4. Testing.

A permanent instrumented test range is available at NWC to conduct full-scale experiments on existing and developmental components, parts of aircraft, and complete aircraft that are tied down and running at full thrust with simulated in-flight airflow velocities. NWC has the only facility in the country capable of conducting gunfire testing on full-scale jet aircraft with fuel systems and engines operating. Fully operational fighter aircraft can be mounted on a 360-degree rotatable test stand and operated at full thrust. In addition to gunfire testing, the flexibility of the facility also provides a unique and ideal test arrangement for aircraft IR (infrared) signature measurement, laser reflectivity testing, etc. Various aircraft are available at the main test site for IR signature testing. The aircraft can be rotated through various yaw positions with respect to IR measurement instrumentation while remotely operating the engine in military power and afterburner.

Tests are conducted to determine the ability of aircraft, systems, or components to continue functioning after being hit by projectiles, fragments, or blast from air-to-air and ground-to-air guns and missiles. Full-scale tests have been conducted on F-84, F-86, A-4, A-7, and F-14 aircraft. F-14 and C-130 subsystem tests have been conducted. Research and development tests are being conducted continuously.

SURVIVABILITY/VULNERABILITY

Aircraft Survivability Range

The Aircraft Survivability Range, located at the NWC K-2 ground range, provides a secure, remote base for operations. The range consists of three areas:

1. Test Specimen Preparation Area
2. Ballistic Test Area (having four test pads with a central instrumentation and control room)
3. Full-scale Fire Survivability Burn Test Facility.

Most of the developmental and support work is done at the test specimen preparation area. The main test site is used for firing tests and data collection.

Related Ballistics Ranges

NWC has several ranges for ballistic testing. The ranges of interest for this report include:

1. Small-Caliber Gun Range
2. Gun Target Range
3. Missile Firing Ranges

4. Missile Ballistic Ranges
5. Rocket Target Range
6. Simulated Air-Launch Range

Although the above ranges are not specifically used for aircraft S/V testing, they do provide ballistic test capabilities that could augment the Aircraft Survivability Range. The NWC test ranges are shown in Figure H-1.

ACCESS

Highways 6, 14, 178, and 395 provide road access to NWC. Commercial air transportation is available from Los Angeles, Inyokern, Mojave, and Palmdale, CA. Military air transportation is available at NWC, Armitage Field, and Edwards Air Force Base. The Southern Pacific Railroad provides rail access to NWC, and the Port of Los Angeles provides the closest sea access and port facilities.

MAINTENANCE/FABRICATION CAPABILITY

The Test Specimen Preparation Area, located on the Aircraft Survivability Range provides an area for the calibration, repair, and storage of instrumentation and aerospace equipment and for the modification repair and instrumentation of test aircraft and experimental test specimens.

This compound is enclosed by an 8-foot-high chainlink and barbed-wire fence, with an 80-foot-wide gate for aircraft access. Within the fence is an engine run-up pad, a shaded service and general work area, an unshaded aircraft parking ramp and service area, a machine shop, and administrative offices. It can handle two to four aircraft at a time, depending on aircraft size. This compound has complete equipment for (1) modifying and repairing aircraft and engines for S/V testing; (2) constructing, modifying and repairing experimental test specimens; and (3) installing cameras, transducers, servos, thermocouples, and other instrumentation needed for specific tests. Adjacent to the preparation area is a similarly fenced and gated 6-acre area for the storage of aircraft and parts.

The Airborne Instrumentation and Flight Test Branches of the Test and Evaluation Department also provide support for modifying aircraft to carry developmental or prototype air weapon systems; install avionics, electromechanical subsystems, and launching mechanisms for experimental weapons; and design, fabricate, and install instruments expressly devised for special test requirements.

LOGISTICAL SUPPORT CAPABILITY

The NWC Supply Department provides logistical support to all test activities. Support activities located within the Test and Evaluation Department include:

1. Facilities Planning Group
2. Meteorological Services
3. Telemetry Services
4. Data Reduction.

Ammunition storage magazines are available at the various ballistic ranges.

INDOOR FACILITIES

None.

OUTDOOR FACILITIES

AIRCRAFT SURVIVABILITY RANGE

Dimensions

The main test site (Figure H-2) on the range consists of a 60- by 60-foot elevated concrete test pad with a 40-foot-wide approach ramp and tie-down stand that can support a 100,000-pound aircraft with engines operating up to 50,000 pounds thrust, a gun tower so that guns can shoot into any desired area of the aircraft, a high velocity airflow system, and test support equipment. Nominal firing range is 60 to 80 feet. The maximum firing range depends upon accuracy of weapon used.

C1 test pad, used for testing aircraft subsystems and components, is located 300 feet north of the main test site.

C2 test pad is located directly adjacent to the main test pad. It is a 65- by 90-foot-pad consisting of "T" slots embedded in concrete at 10-foot-intervals, with underground conduits for CO_2 electrical controls, power and instrumentation, compressed air, and jet engine blast deflector, and strategically located camera support boxes. This test pad can support tests requiring fully operational aircraft with simulated in-flight airflow.

The Test Specimen Preperation Area is a 3-acre area enclosed by an 8-foot-high chainlink and barbedwire fence, with an 8-foot-wide gate for aircraft access. Across the street is a similarly fenced and gated 6-acre area for storage.

Weapons/Projectiles Available

The facility accommodates U.S. and Soviet weapons from 7.62- through 40-mm (Soviet projectiles through 57-mm). Fragmentation rounds are fired from a .60 caliber and 30-mm smooth-bore guns. Multifragment firings are accomplished with a light gas gun. A 1/2-inch bore powder gun is available. A 2.5-inch bore light gas gun is also available.

Environment

A new high-velocity airflow system provides velocities up to 550 knots airflow over sections of the aircraft. A 48-inch-diameter duct may be utilized to adapt various duct extensions which may be configured as required for specific test requirements.

Facilities are available to chill small quantities of fuel for explosive testing.

Simulated flight loads to test specimens can be provided when required.

Live/Inert Fire

Live projectiles (7.62- through 57-mm), single fragments and multiple fragments can be fired at the facility.

Safety (and Security) Requirements

A closed circuit color television system, high noise communication system, public address system with warning light, and a siren are used for area safety and control.

There are two remotely controlled firefighting systems: CO_2 (primary) and water deluge. Additionally, a semiportable cart containing light water and purple-K and a manned fire truck are available for all tests. The CO_2 is held in an 8-ton tank and piped to the impact area or to special manifolds having dispensing networks connected to the aircraft. An on-site well and a 10,600-gallon capacity storage tank supply water to the deluge system. This system sprays the entire test pad area from several heads mounted on its perimeter. Spilled fuel and water are controlled by curbing and a large capacity drainage system.

The facility is located within a secure, guard-protected complex providing the necessary security precautions for firing classified weapons.

Power Availability

Electrical power at the facility includes 500 kVA, 3-phase, 60 Hz; 100 kVA, 3-phase, 400 Hz, 115 VAC and 28 VDC, 400-ampere. Aircraft portable power units are also used if required.

Observation/Communication

Two CCTV (closed circuit television) are available at the test site. One remotely controlled system is located in the site blockhouse. Others are used as portable video. Intercoms are used for on-site communication. Two-way radios are used to coordinate with the range radio system. The high noise communication system is utilized around operational aircraft and during test preparation for calibrations and operational checkout of all systems. All voice communications and video systems are recorded during testing.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Projectile velocities and other in-flight data are acquired using chronographs (two on hand, two on order), high-speed photography, and a black and white IR recorder. A pool of instrumentation equipment provides additional capability to the test sites. Table H-1 lists the photographic equipment available from the Photo Branch.

TIMING. Time code generators provide data time correlation. The time code (IRIG-B) is recorded directly on the magnetic tape recorders, oscillograph data, and data films.

TELEMETRY. Instrumentation transducers are hardwired to the recording equipment in the Fire Control Barricade (Blockhouse). Baseband multiplexed data are either recorded on magnetic tape or discriminated and recorded on oscillographs for quick-look and data verifications.

OTHER. There are 97 channels of output from the fire control barricade to the test site. These are used for such operations as turning on cameras, controlling the aircraft engine, firing the gun, and energizing the firefighting systems. During testing an automatic sequence timer controls gunfiring, camera, etc. The wiring from the fire control barricade to the electrical barricade runs in underground conduits. The wiring from the electrical barricade to the test pad junction boxes is in underground conduits, and cables from these boxes to the test aircraft are considered to be expendable.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. Much of the photographic equipment listed in Table H-1 can be used to record projectile/specimen impact.

TIMING. Time code generators provide data time correlation. The time code (IRIG-B) is recorded directly on the magnetic tape recorder, oscillograph data and data films.

TELEMETRY. All terminal ballistic data transducers are hardwired to the Fire Control Barricade where the information is recorded on magnetic tape or oscillographs or displayed on various types of monitors. Transducers are available for measuring:

1. Strain (tension or compression) to 24,000 microstrains
2. Temperatures from -200° to +2000°F
3. Pressures to 100,000 psi
4. Accelerations to ±5000 *g*'s
5. Firing rates as required.

OTHER. The following signal conditioning equipment is available in the Fire Control Barricade (Table H-2).

Environmental Simulation and Measurement

Two (one 95-knot maximum and one 550-knot maximum) airflow systems are available. The air can be cooled by 100°F maximum using cyrogenics. Simulated flight loads can be applied to the test specimen as required (using hydraulic jacks and wiffle trees).

Planned Expansion Modification

A proposed modification program, to span a 3-year period beginning with FY 1975, will include:

1. Modification to intersite cabling conduits
2. Addition of underground instrumentation area
3. Providing cable terminators in junction boxes at each site
4. Addition of a second main power transformer
5. Procuring additional required instrumentation
6. Procure microwave link with main laboratory Univac 1110 computer for data reduction.
7. Lightwater (AFFF) fire extinguishing system
8. CDC-8090 computer system.

The modifications will increase instrumentation flexibility and minimize instrumentation setup time.

SMALL-CALIBER GUN RANGE

The Small-Caliber Gun Range and the ballistic test facilities to follow, although not presently used for S/V testing will be briefly discussed to point out the additional ballistic test capabilities available at NWC.

Dimensions

The Small-Caliber Gun Range is a 1000-meter range used for the study of the exterior ballistics of 20-mm projectiles from firing through impact.

Weapons/Projectiles Available

Although designed for testing 20-mm ammunition, the range can be used for gun tests of weapons systems up to 30-mm in size.

Environment

None (other than ambient) available at this facility.

Live/Inert Fire

Live ammunition can be fired on this range.

Safety (and Security) Requirements

Standard range safe operating procedures are used at the facility.

The range is located in a secure area and can accommodate classified weapons.

Power Availability

Aircraft-type electrical power and high-pressure air are available to the gun-mounting pads. Utility power is available to the test-control building.

Observation/Communication

Two-way radios, intercoms, and cameras provide observation and communication between the test-control building and test specimen.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The range is uniquely instrumented for gathering high-speed, to 1 million frames/sec, stop-motion photographic data on projectiles in flight, and for the operational components and operational cycle of aircraft machine guns. A system of mirrors and high-intensity lighting allows a single camera to record on a single filmstrip five images that give a 360-degree coverage of a projectile in flight. This technique produces photographic signature patterns for various conditions of pitch and yaw. The technique can also give data on velocity and change of attitude with time by the use of two or more multiple-image photographic stations. This is only one of several NWC-developed techniques, which when combined with high-speed synchro-ballistic cameras, yield high-quality, clear, detailed images of test projectiles in flight.

TIMING. Time code generators and counters are used for timing reference.

TELEMETRY. The majority of the transducers are used for gun functions and terminal ballistic data.

OTHER. Velocity coils and an ultra-high intensity narrow beam light source are available also.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The photographic equipment listed in Table H-1 can be used as required on the Small-Caliber Gun Range.

TIMING. Time code generators and counters are used for data time correlation.

TELEMETRY. Transducers are hardwired to the test control building. Typical parameters include:

1. Strain (tension or compression) to 24,000 microstrains
2. Temperatures from -200° to +2000°F
3. Pressures to 100,000 psi
4. Accelerations to ±5000 *g*'s
5. Firing rates as required.

OTHER. Tests requiring transducers not immediately available at the range can be accommodated using equipment from the instrumentation pool.

Environmental Simulation and Measurement

Not applicable to this facility.

Planned Expansion/Modification

No expansions or modifications to the facility are currently planned.

GUN TARGET RANGE

Dimensions

This Range is used for firing of projectiles from major caliber guns to measure fuze sensitivity and fuze patterns and to determine how variation of the aspect of the target affects fuze performance. Part of the facility is a howitzer range, where a variety of fuzed projectiles are fired to collect data on burst heights and on fuze-arming performance.

Maximum firing range using a one-shot Mann Barrel is 1000 meters. Greater firing ranges can be accommodated, but these depend largely on projectile flight path and desired accuracy.

The range areas are on a wide expanse of relatively flat terrain that is backed up by mountains at distances from 7000 to 20,000 yards. The focal point of range operations is the gun-line area, where naval guns and rocket launchers fire projectiles and small rockets for fuze tests. At the target area, two wooden target towers are used to suspend large targets in an environment that minimizes the extraneous reflections seen by the fuze. Downrange, an instrument building 4000 feet off the line of fire provides an unobstructed view of targets suspended between the towers. This building houses instrumentation for burst-position spotting, camera control, and fuze-signal monitoring. The gun-line area includes a storage and temperature-conditioning building, gun-crew shelters, and an extensive underground system of power, communications, timing, and signal lines.

Weapons/Projectiles Available

Permanently mounted 3"/50, 5"/38, 5"/54, and 6"/47 naval guns and rocket launchers are available to fire projectiles and small rockets for fuze tests. A mobile-gun road extending behind the gun-line permits testing with long-range mobile guns by emplacing the guns along the road at positions where their firing range to the target area is greater than that from the gun-line.

Environment

None (other than ambient) available at this facility.

Live/Inert Fire

Live ammunition and small rockets can be fired on the range.

Safety (and Security) Requirements

Range safe operating procedures are followed for all ballistic tests.

All test operations of this range are controlled from the control center on the second floor of a three-story test control building at the gun-line area. This reinforced concrete building is safe for occupancy under all test firing conditions.

The entire range is located in a secure area and can accommodate classified weapons if required.

Power Availability

Utility power is available in the instrument building and test control building.

A network of power lines (and signal lines) allows utilization of portable instrumentation.

Observation/Communication

Fragment-resistant windows in the control center give test conductors a clear view of the gun-line area. Behind the test control building is a 50-foot-high steel spotting tower that can be moved along a 300-foot track and positioned behind any of the guns to look along the line of fire. From within the tower, experienced spotters with telescopes locate the burst position of each round and relay the information to the control center.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed cameras such as those listed in Table H-1 can be used to record in-flight data.

TIMING. IRIG time code generators and digital counters provide data time correlation.

TELEMETRY. The instrumentation on this range is used to evaluate fuze performance and not projectile in-flight ballistics.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. CCTV cameras record burst position around the target. The top of the test control building is available for mounting cameras and other instruments to record miss distance.

TIMING. IRIG time code generators and digital counters are used for data time reference.

TELEMETRY. The electronic instrumentation is used to monitor and record fuze signals. Additional instrumentation is available from the instrumentation pool.

The network of signal and power lines allows portable equipment to be readily installed at various points on the range.

Environmental Simulation and Measurement

Not applicable to this facility.

Planned Expansion/Modification

No expansion or modification are currently planned.

FULL SCALE FIRE SURVIVABILITY BURN TEST FACILITY

Dimensions

This facility is currently under construction at the Aircraft Survivability range at NWC and is scheduled for completion in December 1977. When completed this will be the most elaborate of the fire test installations at NWC. This installation will consist of a 100- by 100-foot concrete burn test pit constructed over an instrumentation room. This room will be accessable through a 150-foot long, 7-foot-diameter tunnel which will run from a fire control building completely under the burn pit area. This test facility will make it possible to place large or delicate instrumentation as close as possible to the test item. The blockhouse at this site will house all required instrumentation and recording equipment and will be tied to the main fire control.

Weapons/Projectiles Available

Not applicable to this facility.

Environment

Chemical and toxic fire environments can be provided in the concrete burn test pit.

Live/Inert Fire

Not applicable to this facility.

Safety (and Security) Requirements

The fire fighting system currently being installed for this area consists of a high volume light water system capable of 300 gal/min flow of light water. The entire facility is located in a secure area.

Power Availability

Utility and instrumentation power are available in the instrumentation room.

Observation/Communication

Photographic and visual observation from safe distances is permitted.

Two-way radios and a public address system are available for communication.

Instrumentation

In addition to the normal instrumentation such as, photographic, timing, recording and data reduction capability, the following specialized equipment is available at this location.

CHEMICAL AND TOXIC EQUIPMENT. To provide the capability to identify and quantify gas species from the fire environment, a programmable gas capture system is available. This unit consists of twenty (20) fifty (50) M1 flasks which have programmable high vacuum solenoid valves for capturing gas samples at desired intervals during a test. The circulated gas flow to and from the test item is achieved by means of a stainless steel diaphram gas pump which circulates the gas into the flasks. Upon the completion of the test, gas samples are removed as desired from incorporated septum tee's and analyzed using a gas chromatograph and then a mass spectrometer. In addition to this unit, on-line gas data are available from different sensors. CO and CO_2 are monitored with a Beckman IR sensor. NO and NOX are monitored with an Aero-Chem chemiluminescent sensor. The halides, cyanide and any other chemical species of interest are monitored using specific iron electrodes. Animal data can also be extracted by use of EKG data equipment.

HEAT FLUX AND TEMPERATURE CHARACTERIZATION. Traditional calorimeters such as the Gardon and thermopile design are used to meausre heat flux intensity and history. Expandable flux meters made of Armco iron using NWC designs are attached to test items to measure both the direction and intensity of heat as a function of time. Capability exists for measuring the temporary spectral distribution of heat in fuel fires.

Temperatures are measured with miniature thermocouples of either the bead or ribbon construction.

MECHANICAL, OPTICAL AND SMOKE CHARACTERIZATION. High temperature strain gage technology is used measuring structural deformation in a fire environment. New techniques are being developed to meet the various meausrement requirements.

A 16-mm movie camera equipped with a 120-degree field-of-view wide angle lense has been packaged within an insulated water jacket and is designed to be used within a test item during a fire.

Smoke is measured with an expendable apparatus which has been calibrated with both neutral density filters and smoke in the NASA-NBS smoke chamber.

TELEMETRY. A transmitter with self-powered electronics exists with a 120 channel capability. This electronic package has been packaged within an insulated water jacket and is designed to be used within a test item during a fire.

MISSILE FIRING RANGES

Guided Missile Range

The Guided Missile Range is used to conduct tests and evaluation of air-to-air, surface-to-air, and surface-to-surface guided missiles, rockets, and fire-control systems; captive-flight tests of aircraft missile and rocket armament. The range is also used for evaluations of shipboard gun and missile fire-control system components, launchers, and radar-deception rockets.

The range centers on the main missile line of fire, which runs through the approximate center of the China Lake complex from the southern edge of the dry lake to the north boundary. The operations and support facilities are at the south end of the line and the test area extendes downrange from them to the north boundary in a 35-degree-wide, 37-mile-long sector. Most of the fixed cinetheodolites of the weapon system test ranges are emplaced along the east and west edges of this sector; they provide continuous high-altitude (to 100,000 feet) coverage over the entire length of the missile line of fire and ground-level-to-high-altitude coverage over its first 18 miles. Within the test area, there are 75 precisely surveyed instrumentation sites on which mobile cintheodolites, tracking mounts, and precision photographic and video cameras can be emplaced to furnish additional or close-in coverage as required. Spotting towers are also available to cover frequently used impact zones, and reinforced instrument shelters for remotely controlled film and TV cameras are available in high-hazard areas.

Special test areas include two downrange installations equipped and instrumented to fire chaff-dispensing rockets and to collect data on the size, shape, density, and dispersion rates of the resulting chaff clouds; several firing sites at which up to 26 precision-orientation cameras can be set up to cover selected preplanned missile flight paths; and the Small-Missile Range. There is also a pool of 60 radar transmitter-antenna combinations that can be sited anywhere on the test ranges and remotely operated as targets for antiradiation weapons and seekers. These stripped-down radars are used either singly or in clusters to simulate various RF radiation, interference, or

deception environments. Facilities in the operations and support area include the range control center; a control building and launching ramps for BQM-34A target drones; missile launchers and movable barricades; shelters for weapon systems under test, connected by underground cableways to reinforced pads for launchers and heavy gun mounts; assembly, check-out, storage, and conditioning buildings for missiles and rockets; and ammunition magazines.

Major instrumentation includes several tracking radars operating in the C- and X-bands, capable of either skin or beacon tracking. A CDC-1700 and two Univac 1218 digital computers and peripherals are used for data processing, storage, and realtime display. Three sets of large XY and H plotting boards are used for simultaneous display of launching aircraft, missile, and target space positions during air-to-air engagements. TAS control center and microwave data links to MIDAS sites and video laboratory; timing generation, telemetry, and remote instrument control facilities; emergency in-flight destruction command system for experimental hardware; and ground-to-air AM UHG and ground-to-ground FM VHF voice communication and data link equipment sufficient to coordinate and control all air and ground operations on the weapon system test ranges during tests or evaluations entailing concurrent activities at several facilities are also available.

Small-Missile Range

This range is used for tests of short-range surface-to-air guided missiles against low-flying aerial targets, field evaluations of small tactical air-defense systems, and preflight tests of experimental air-to-air guided missiles and rockets. The range is used primarily for test activities entailing potential hazards from developmental ordnance of unproven reliability or from damaged, out-of-control target drones.

The facility consists of a range-control blockhouse, steel-plate protective barricades for personnel and equipment, shelters and platforms for mobile instrumentation, and launching pads. It is located about 5 miles north of the control center of the Guided Missile Range, and is essentially a subfacility of that range, sharing its airspace, downrange area, fixed electronic and optical instrumentation, drone launchers, missile assembly and check-out buildings, and support facilities.

Targets available for surface-to-air firings include drones, towed targets, target rockets, flares, and tethered balloons. Missiles can be launched at almost any angle against approaching targets. Launchers may be manned or remotely controlled from the blockhouse, and lightweight trainable launchers can be emplaced on the blockhouse roof to facilitate acquisition and tracking of small low-flying targets (CCTV enables controllers in the blockhouse to monitor the behavior of launchers and missile throughout a tracking and firing sequence). If desired, full documentary photographic coverage of any test activity - including launch-to-impact photography of short-range surface-to-surface firings along preplanned trajectories - can be provided with mobile instrumentation.

MISSILE BALLISTIC RANGES

Exterior Ballistics Range

This facility is used for tests of ballistic and small guided missiles under simulated aircraft launch conditions, especially for gathering data of launching and early flight parameters, test of ground-launched rockets and small surface-to-surface ballistic and guided missiles, and studies of projectile ballistics.

One of the installations on this range is a 550-foot launching ramp, elevated 6-degrees from the horizontal. On it, a rocket-propelled sled can produce predetermined launch velocities up to Mach 1 (for the firing of aircraft weapons from simulated aircraft under precisely controlled conditions). Heavy instrumentation at the fire point allows detailed study of aircraft/weapon separation characteristics and weapon ballistics. This, combined with the downrange instrumentation shared with the Guided Missile Range, provided coverage of a weapon trajectory from launch to impact. The elevation of the ramp and the flat terrain in front of it give long trajectories.

The operations and support facilities of the range are at the south end of the main missile line of fire just east of the Guided Missile Range control area. The test area overlaps the Guided Missile Range and covers a 35-degree-wide, 37-mile-long sector. The two ranges share the downrange areas and instrumentation. The first 18,000 yards of the range are kept free of duds (normally only inert weapons are fired) so that bits and pieces of a fired weapon can be recovered for analysis. When needed, chemical and metallurgical analyses of such recovered items are furnished by the NWC Research Department.

Fixed launch equipment includes a two-cell ASROC launcher and Mk 102 and Mk 105 autoloader, 5-inch barrage-rocket launchers, and several universal rocket-launching pads and launchers. The gun facility has 5"/38, 5"/54, and 3"/50 naval gun mounts for firing projectiles. In addition, other guns are available at the Small-Caliber Gun Range, and Fuze Ranges. Facilities in the control area include a test control building, an assembly and check-out building with temperature-conditioning chambers that handle weapons up to 20 feet long and 4 feet in diameter, and magazine storage for all classes of explosives.

The range has many kinds of downrange instrumentation. Processing and storage of data are done by the computers at the Guided Missile Range control center. Numerous instrument sites are available close-in for film and TV cameras to cover early missile flight. Camera coverage of an entire missile flight is available. A link to the video instrumentation laboratory can give realtime video coverage. Also, digitized instrumentation radar is available for projectile trajectory data. A mobile telemetry receiving van is moved in when required to supplement the primary telemetry receiving facility located at the Air Weapons Range.

Terminal Ballistics Range

This range is used for terminal ballistics testing of fuze and warhead performance and of fuzing results by striking targets of various sizes (from massive to very small and thin) at an exact point and with precisely controllable striking velocity and striking angle (by rotating target). Some telemetered warhead effectiveness testing and some crosswind firings of small-caliber guns at high speed are done on this range. Also, a subfacility is available for studying the blast effects on flying projectiles and fuzes by firing sabot-encased models from an 8-inch, smooth-bore gun through a controlled explosive blast.

The range is located on relatively flat terrain at the edge of the dry lakebed area. The primary installation is a two-rail, 1500-foot track on which very inexpensive sleds can be propelled at speeds up to 3300 feet/sec and accelerations up to 125 g. The sled, which consists of inexpensive extruded shoes that fit between or clamp onto the rails, can be separated from the test item at the end of a run (by a blow-apart explosive bolt) so that it does not interfere with the test. Control and support facilities include a test-control building, temperature-conditioned assembly building, storage building, magazines, and limited machine shops (in which sleds are built). Most Navy rocket fuzes have been tested at this track, which is one of only two such installations in the country.

The range includes a subfacility for gathering experimental data on scale models of weapons and weapon components flown through a blast field. A smooth-bored, 8-inch, standard Navy gun fires sabot-encased models at predetermined velocities ranging from 3000 to 5500 feet/sec. A precise sphere of 500 pounds of TNT is suspended above a 6-foot-thick, hardened concrete pad directly in the line of fire. Model speed and explosive detonation are synchronized to optimize the desired blast effects for individual tests.

Portable instrumentation for measuring strain, shock, temperature, vibration, blast pressure, and telemetering data is set up to meet the needs of individual tests and is removed when not testing. Detailed photographic coverage is available.

The 8-inch gun facility has camera mounts to accommodate high-speed cameras for photographing the model as it enters the blast wave.

SIMULATED AIR-LAUNCH RANGE

The Air-Launch Range is used for testing of air-weapon fuzes by launching small missiles and rockets from a mountain top toward target areas on neighboring hillsides and valleys. Launch angles and impact angles and positions can be precisely controlled in a ground environment that closely simulated air-launch conditions (except for forward speed of the launching aircraft).

The range is located in a remote mountainous area in the northwest sector of the China Lake complex. It utilizes the unique terrain features of the area to provide a ground-launch facility that closely simulates most of the characteristics of

an air-launch and an air-to-ground trajectory. Three launch pads on top of a steep-sided mountain allow weapons to be launched at various angles (including steep angles simulating launches in a dive attitude) at target areas from 4000 to 15,000 feet away. This range is based on the same principle as the Rocket Target Range (providing a line of fire when no ground surfaces intrude on the hemisphere in front of the fuze), but much steeper firing angles and variable firing ranges are possible here. This range provides a capability for testing fuzes in combination with warheads and rocket motors that have not yet been approved for air firing. Additionally, it allows for closer control of impact positions than is possible with air launches.

The support equipment on the site varies from test to test. Mobile instrumentation, communications, etc., are utilized in support of individual tests as required.

DATA HANDLING/PROCESSING

All NWC computing activities are through one of 106 on-post terminals connected to the Central Computing Facility. Card handling and keypunch equipment are available for general use.

DATA STORAGE AND RETRIEVAL

Data can be stored and retrieved for subsequent use on drums, magnetic tape, or high-speed disc. Table H-3 shows the storage available at the facility.

QUICK-LOOK CAPABILITIES

The quick-look capability of each terminal depends upon the type of terminal in use, but in general, teleprinter hardcopy and CRT displays provide this service.

Oscilloscopes, oscillographs, and counters provide quick-look data at many of the individual ranges.

PROCESSING

System and Model

The primary processor at the NWC Central Computing Facility is a Univac 1110 computer configured as shown in Figure H-3.

Language

The language processors available for the system are:

1. 1110 Assembler
2. FORTRAN V
3. CFOR
4. 1100 DOD COBOL
5. ASC II/ANS I COBOL
6. PDP
7. UBASIC
8. RFOR.

Input/Output Options

The NWC 1110 Computer system contains a full complement of input/output devices including:

1. Card Reader
2. *Card Punch*
3. Paper Tape Reader
4. Printer
5. Demand Terminals.

Realtime/Interaction

Realtime programs are available to support specific tests.

DISTRIBUTION

Data turnaround time, if processed at the facility, is usually 24 hours or less. Otherwise, the terminals provide data on a time-share basis. Large jobs are processed by priority.

DISPLAYS

Numerous display devices are available. Typical displays include:

1. CRT's
2. CCTV
3. Digital counters
4. Oscillographs
5. Teleprinter hardcopy.

Display instrumentation varies from range-to-range and can be augmented by equipment from the instrumentation pool.

REFERENCE DOCUMENTS

1. *NWC Aircraft Survivability Ballistics Test Facility*, Technical Note 3014-048, Naval Weapons Center, China Lake, CA, June 1972.

2. *Facility Customer's Guide Book for Instrumentation at Aircraft Survivability Range*, Technical Note 3014-056, Naval Weapons Center, China Lake, CA, May 1973.

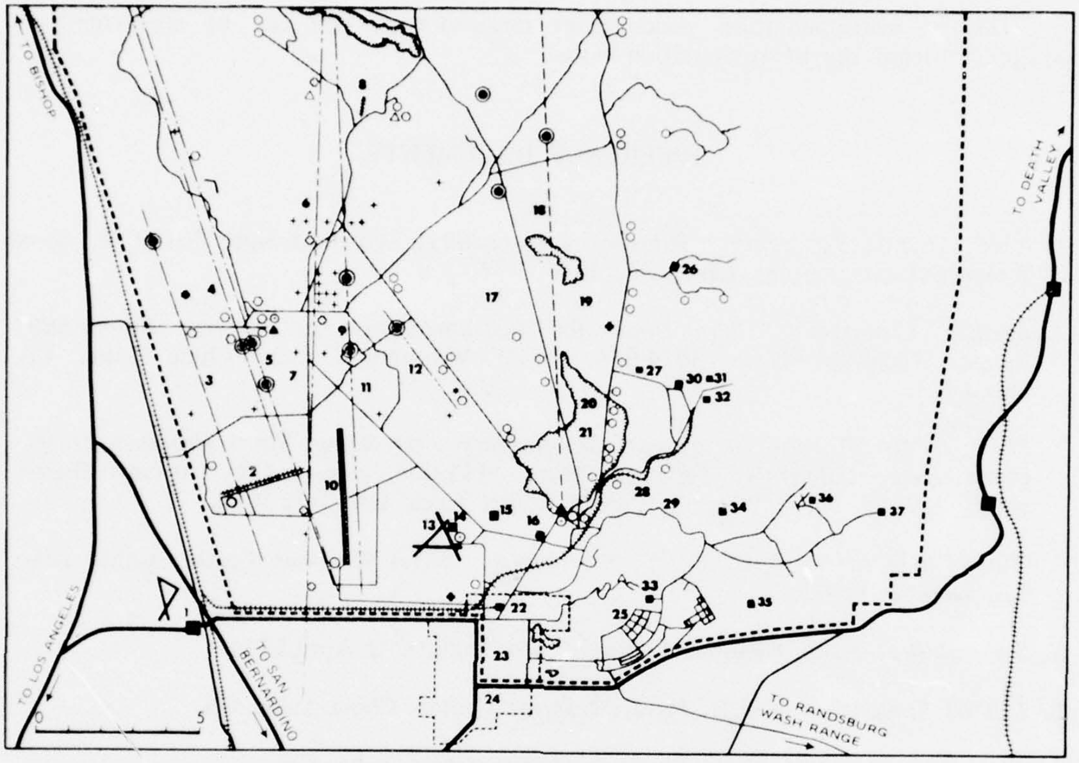
3. *Plan for Modification of Aircraft Survivability Test Range Naval Weapons Center - China Lake, California*, Technical Note 5111-006, prepared by Aircraft Survivability Branch, Naval Weapons Center, China Lake, CA, July 1974.

4. *Your Guide to the NWC Computing Facility*, Naval Weapons Center, China Lake, CA, October 1973.

5. *Survivability*, Naval Weapons Center, China Lake, CA, April 1974.

6. *List of Simulation Models*, Naval Weapons Center, China Lake, CA.

7. *NWC Test Facilities*, Naval Weapons Center, China Lake, CA.



1. Inyokern
2. Transonic Test Track
3. B2 Flight Line
4. B1-C Flight Line
5. B1-B Flight Line
6. BL Flight Line
7. Air Weapons Range
8. Exterior and Terminal Ballistics Test Track
9. C-3W Flight Line
10. Supersonic Naval Ordnance Research Track
11. Air Tactics Range
12. C-1 Flight Line
13. Naval Air Facility
14. Boresight Range
15. Thompson Ballistic Laboratory
16. Explosives Research and Development Test Range
17. Guided Missile Range
18. Main Missile Line of Fire
19. Exterior Ballistics Range
20. Small Missile Range
21. China Lake (Dry)
22. Michelson Laboratories
23. China Lake Community
24. Ridgecrest
25. China Lake Propulsion Laboratories
26. Large Warhead Research Test Range
27. Aircraft Survivability Range
28. Crosswind Firing Range
29. Magazine Area
30. Explosives Studies Range
31. Small-Caliber Gun Range
32. Terminal Ballistics Range
33. Live-Ordnance Environmental Test Facilities
34. Air Augmentation Facility
35. FAE Firing Test Range
36. Static Test Range
37. Weapons Safety Test Range

○ Theodolite Station
○ Flightline Recorder
△ Radio Communications Repeater
• Profile Plotting Tracker
○ Range Control
▲ Tracking Radars & Plotting Boards
○ Telemetry
● MIDAS Antenna Field
◉ Target and Impact Area
\+ Photogrammetric Markers

Figure II-1. China Lake Facilities Layout.

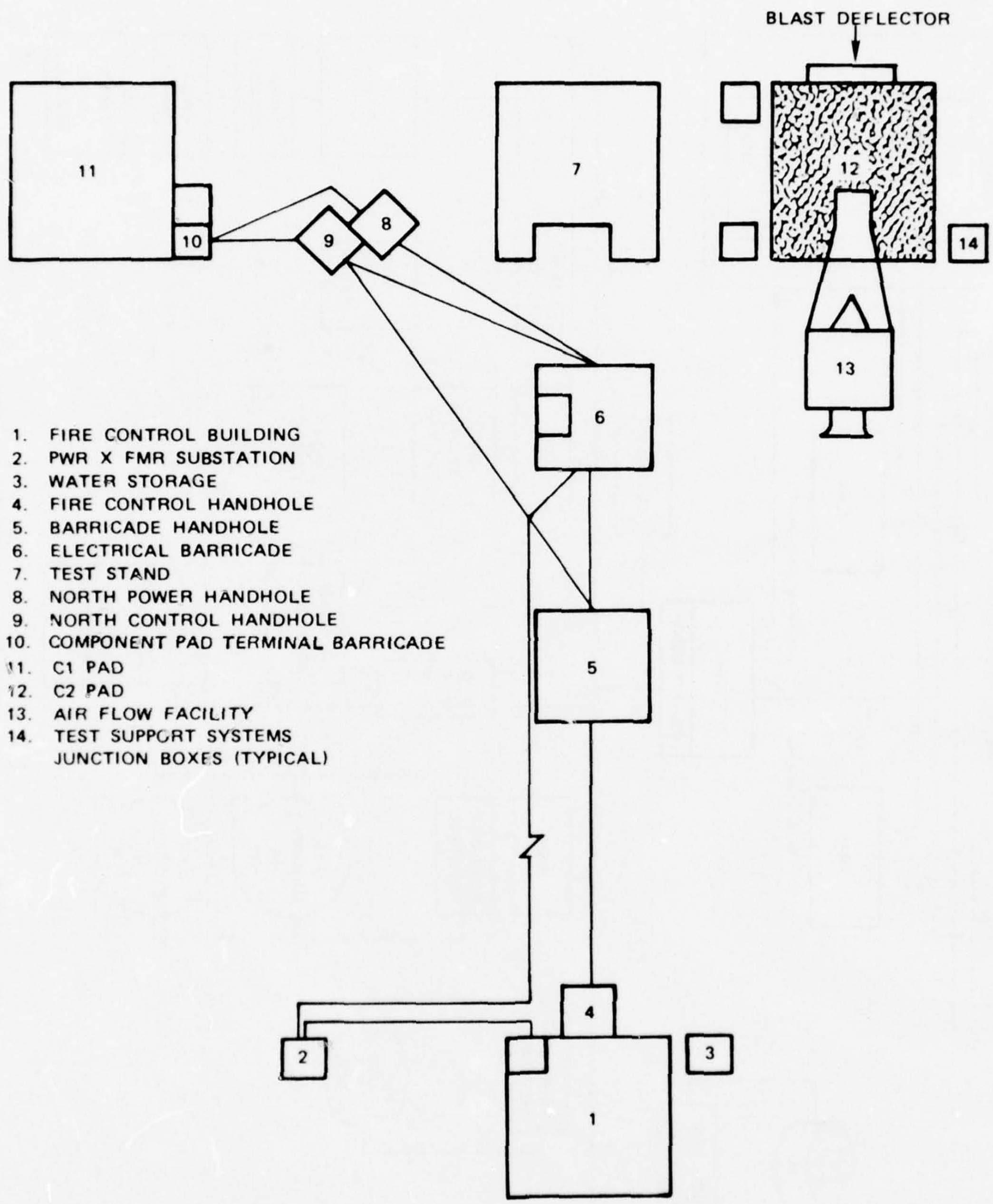


Figure H-2. Aircraft Survivability Main Test Site.

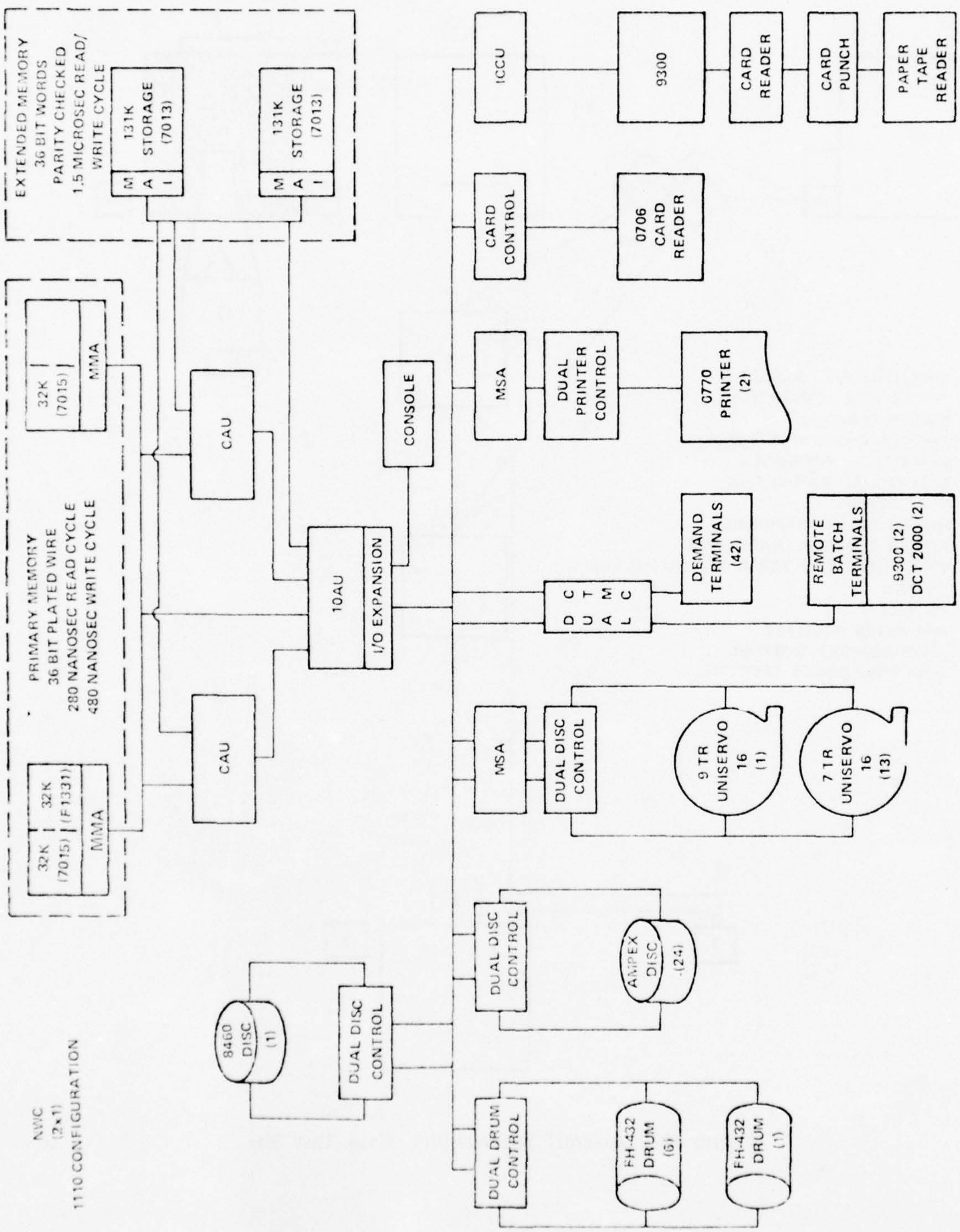


Figure H-3. Configuration of Univac 1110 Computer.

Table H-1. Photo Branch Photographic Support.

Visual Instrumentation Cine	8 High-speed/pulse cameras. Super-8 x 50 foot cartridge. Cine - 10 frames/sec to 250 frames/sec pin registered. 1 to 20 pulses/sec.
Milliken DBM-4	16-mm x 200 foot pin registered. 4 to 400 frames/sec. 100- and 200-foot daylight spool.
Milliken DBM-5	16-mm x 400 foot pin registered. 100-, 200-, and 400- foot daylight spool.
Mitchell	16-mm high-speed pin registered. 12 to 400 frames/sec. 400-, 1200-, and 1600-foot darkroom load.
Photo-Sonic 16-mm-1W	High-speed 24 to 1000 frames/sec. Pin registered 100-, 200-, and 400-foot daylight spools.
Photo-Sonic 16-mm-1B	High-speed 100 frames/sec. Rotating prism. 100-foot daylight, 200- and 400-foot darkroom load.
Fastex WF-4	16-mm prism high speed. 1000- to 8500-frames/sec. 100-, 200-, and 400-foot daylight spool.
Redlake Hycam Model 41	16-mm prism 120 to 11,000 frames/sec. 100-, 200-, and 400-foot daylight spool.
Redlake Hycam Model 42	16-mm prism 100 to 5000 frames/sec. 2400 foot darkroom load.
Flight Research Model IV E	35-mm pulse up to 20 pulses/sec. 400 foot darkroom load.
Mitchell 35 High-speed	35-mm pin registered 12 to 120 frames/sec. 400 and 1000 foot darkroom load.
Photo-Sonic 35-mm-4B	35-mm prism 100 to 2000 frames/sec. 400 and 1000 foot darkroom load.
Redlake Hytax Model 61	35-mm Ballistic Synchro (Streak) 30 to 250 ft/sec. 100-, 200- to 400-foot daylight spools.
Hulcher Model 105	70-mm sequence 5 to 20 frames/sec. 100 foot daylight spools.
Photo-Sonic 70-mm-10A	70-mm pin registered 20 to 60 frames/sec. 1000 foot darkroom load.

Table H-1. Photo Branch Photographic Support. (Contd.)

Nikon F Single Lens Reflex	35-mm still camera. Motor drive and magazine for sequence pictures up to 3 pictures/sec.
Lenses from 10-mm to 24 inch	For motion picture cameras.
Timing Lamp Capability	On all motion picture cameras.

Table H-2. Signal Conditioning Equipment.

Type	Use	Quantity
Voltage regulated resistance bridge signal conditioner	1, 2, or 4 active elements: 2 to 10 wire systems; single or double shunt calibration; excitation adjustable 1 to 30 Vdc or resistance programmable.	10 channels with 2 spare units
Current regulated resistance bridge signal conditioner	Excitation adjustable 0.5 to 50 made for 1, 2, or 4 element bridges; 2 to 8 wire systems terminals provided for bridge completion, bridge balancing and calibration resistors.	60 channels
Thermocouple signal	Adapts to a wide range of thermocouple and other mV sources. Bias voltage adjustable ±9.5 mV to set zero output. Up to eight steps of voltage insertion calibration. Span adjustable for selection of full scale.	100 channels
Charge amplifier	Piezoelectric transducers a. Pressure pickups b. Force gages c. Impedance heads.	12 channels
Carrier amplifier	Linear variable differential transformers and variable reluctance transducers.	1 channel
Conditioning amplifier	Amplifies low-level DC and AC voltages and provides impedance matching and solution between the voltage source and subsequent equipment.	
Galvanometer amplifier	Amplifies signals from transducers with 1 volt or more signal and an impedance of 10K ohm or less. Will amplify from DC to 8 kHz. The output of the amplifier is designed to drive galvanometers or other recording instruments having a low driving resistance, high current (up to 65 mA) requirements.	2 each

Table H-2. Signal Conditioning Equipment. (Contd.)

Type	Use	Quantity
Galvanometer amplifier	Amplifies signals from transducers with voltage outputs from 0.1 to 300 volts with 0.5- to 3-inch peak galvanometer deflection.	2 each
Oscillograph	32 channel light beam oscillograph providing realtime data display and data reduction capability. 200 IPS naper speed with 25 kHz bandwidth.	1 each
Oscillograph	10 channel, 160 IPS, 10 kHz bandwidth.	1 each
Scanner	CDC.	1 unit
Synchronizer	CDC Model 162.	1 unit

Table H-3. Central Computing Facility Data Storage.

Univac 1110 Mass Storage

Unit	FH-432 drum	FH-1782 drum	8460 disc drive	Ampex disc drive
Storage capacity, characters	1,572,864	12,582,912	$528.X10^6$	$51.5X10^6$
Number of units	6	1	1	24
Total storage capacity, characters	9,437,184	12,582,912	$528.X10^6$	$1.2X10^9$
Average access time msec	4.3	17	80	30
Transfer rates, characters/sec	1,440,000	1,440,000	500K, avg	416,664

Magnetic Tape Storage

Unit	Uniservo 16 7 track	Univservo 16 9 track
Number of units	13	1
Density, BPI	200/556/800	800/1600
Tape speed, in/sec	120	120
Interblock gap, in.	0.75	0.6
Transfer rate, frames/sec	96K	192K

ANNEX I - INTRODUCTION

OVERVIEW

The ALCOA (Aluminum Company of America) has recently opened the ALCOA Technical Center just outside of New Kensington, PA. The primary mission of the ALCOA Technical Center is to conduct advanced research on aluminum based materials. As part of this mission, ALCOA conducts research on different projectiles against various aluminum armor plates. The ballistic test facility is currently performing tests under contract for the Department of the Army, under Contract No. DA36-034-ORD-3413A. The contracting office is the Frankford Arsenal, NJ.

The ballistic and ordnance test efforts are conducted under the Engineering Design Division of ALCOA Laboratories located at the ALCOA Technical Center. The primary point of contact is Mr. William J. Dewalt of the Engineering Design Division Center, 412-339-6651, ext. 2697. All ballistic testing for ALCOA is conducted in the ALCOA Ballistic Firing Range on Pennsylvania Highway 780, 3 miles from the ALCOA Technical Center and 6 miles from New Kensington, PA. The test facility is located in the middle of an 89-acre open field at the bottom of a swale.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The ALCOA Ballistic Firing Range tests primarily aluminum armor plate targets at various angles of obliquity simulating primarily aluminum armor for pilot's seats and other areas requiring protection. No full-scale aircraft structural testing can be conducted in this facility.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There is only one indoor ballistic test facility located at the ALCOA Technical Center. This facility is 43 feet in length of which 30 feet can be used for ballistic testing. Paper break velocity meters are used along the middle third of the ballistic path. The target area is located inside an aluminum armor plate reinforced room. The facility can handle weapon sizes from 5.56-mm up to and including 20-mm API (armor piercing incendiary) as well as high velocity APT (armor piercing tracer) ammunition.

ACCESS

Primary access to the ALCOA Technical Center Ballistic Firing Range is via U.S. Highway 22 to Pennsylvania Highway 286, then to Pennsylvania Highway 380 and finally to Pennsylvania Highway 780. The facility is located approximately 8 miles northwest of the intersection of Pennsylvania Highway 380 and Pennsylvania Highway 780. Railroad yards in New Kensington have been used by the Range to handle specimens arriving by rail. All airline traffic comes through the Greater Pittsburgh International Airport some 45 miles west of the range.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capabilities at the ALCOA Technical Center are extensive as would be expected for any major manufacturer's research facility. One time items, as well as items normally fabricated by the company can be handled, particularly aluminum armor plate. A projectile loading facility is available at the ALCOA Ballistic Firing Range. The loading area can be used also as a security vault in case of classified weapon usage.

LOGISTICAL SUPPORT CAPABILITY

The primary logistics support is obtained through ALCOA, Military armament is obtained through the Frankford Arsenal contractor's representative. An ordnance bunker is available some 50 feet away from the ballistic range.

INDOOR FACILITIES

ALCOA BALLISTIC FIRING RANGE

Dimensions

The range is housed in a building which is 43 feet long and 20 feet wide. The range itself is some 40 feet long, 8 feet wide and 8 feet high. The ballistic range is divided into two rooms, the launcher room and the target arena. The target arena is encased in two 3/4-inch 5083 aluminum plates.

Weapons/Projectiles Available

Various calibers of launchers, rifled barrels from 5.56-mm up to and including 20-mm launchers, are available at the facility. 5.56 ball, 7.62 ball, .30 caliber armor piercing and ball ammunition can be fired in this facility as well as .50 caliber armor piercing and fragment simulation rounds. 14.5-mm armor piercing (B-32) and API (BS-41) along with 20-mm fragment simulation and APT can be accommodated at this range.

Environment

No environmental simulation can be accomplished in this facility.

Live/Inert Fire

Both APT and API ammunition for 14.5-mm and 20-mm can be fired in this facility.

Safety (and Security) Requirements

Central control coordinates all safety related functions. Doors and interlocking switches prevent firing with the doors open. No personnel are allowed to observe the firings at any time.

Classified material and equipment can be accommodated by the facility. The loading room can act as a classified storage container.

Power Availability

Only 110 and 220 VAC power are currently available at this facility. 28 VDC type current could readily be made available.

Observation/Communication

No realtime observation capability is currently available at this facility.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Only post-flight photography of the target is available at this facility.

TIMING. Two Beckman Berkley Model 7260U timers are used in conjunction with two pairs of paper break velocity meters. The velocity meters are spaced at 10 feet intervals starting at approximately 3 feet from the launch muffler exit.

TELEMETRY. No hardwire instrumentation or telemetry is available within this facility.

Terminal Ballistic Instrumentation

Only post-flight 35-mm still photography is currently at this range.

Environmental Simulation and Measurement

No environmental simulation or measurement capability exists in this facility.

Planned Expansion/Modification

No expansion or modification is known to be planned at this time.

OUTDOOR FACILITIES

There are no outdoor facilities currently at the ALCOA Technical Center.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The ballistic test range data can currently be stored on either a DEC system-10 or one of two 370/158 IBM computers. Access to the 370/158 computers can be accommodated by a Data 100 terminal located in the Engineering Building at the ALCOA Technical Center. No classified data is stored in the computers.

QUICK-LOOK CAPABILITIES

Inspection of velocity information and the armor target plate can be accomplished immediately after the firing. The computer turnaround time for ballistic limits and the strain rate coefficients is normally less than one day.

PROCESSING

System and Model

The ALCOA Technical Center currently uses the DEC system-10 along with two IBM 370/158 computers. One of the 370/158 computers is located at the Technical Center while another is located at the ALCOA Corporate Headquarters in downtown Pittsburgh. Approximately 750 K core is available for user programs on the IBM 370/158 of the ALCOA Technical Center.

Language

The following languages are used at the ALCOA Technical Center: FORTRAN, COBOL, BASIC.

Input/Output Options

Input and output is normally handled through the Data 100 terminal. Computer generated reports are: (1) the listing report of the ALCOA Firing Range (RAFR) and (2) a summary report for the ALCOA Firing Range (RAFRI). Various computer programs are available to analyze the ballistic data. One such program (RCORBLTS) retrieves the necessary information from the stored data to be used as input to other programs. The output from RCORBLTS is then fed into the ALCOA Regression program, which will statistically analyze the data. Another program (RBLC) takes as input the output from RCORBLTS and the regression coefficients and exponents from ALCOA Regression or from a similar statistical regression analysis; compares calculated and actual ballistic limits; and obtains the mean and standard deviation of the differences between the calculated and actual ballistic limits. The calculated ballistic limit is obtained by using the standard strain rate coefficient equation whose coefficients and exponents are the regression coefficients and exponents referred to previously.

Realtime/Interaction

There is realtime and interacting capability at this facility.

DISTRIBUTION

All information at this facility can be provided within a 24-hour period with up to 60 firings being able to be accomplished per day.

DISPLAYS

The primary display for the ALCOA Ballistic Firing Range is the Data 100 terminal located at the Engineering Building in the ALCOA Technical Center.

ANNEX J - INTRODUCTION

OVERVIEW

The BHC (Bell Helicopter Company) of Fort Worth, TX, is the largest division of Textron, Inc. The Greater Fort Worth operations utilize more than 2,200,000 ft^2 of enclosed space on more than 600 acres of land and employs approximately 9000 employees.

Bell has produced more than 20,000 helicopters for its military and commercial customers. Current production commercial helicopters range from the five-place, turbine-powered model 206 to the 12- to 15-place turbine Model 205 and the twin-turbine Model 212. Under development for 1975 delivery are the seven-place Model 206L and the Model 214B "Big Lifter."

Military helicopters currently produced by Bell include the OH-58 light observation helicopter, the UH-1 Series in both single- and twin-engine versions, the 214A advanced utility helicopter, the single engine AH-1G and the twin-engine AH-1J Sea-Cobra. Bell is also a finalist in the competition to develop an AAH (advanced attack helicopter) for the U.S. Army. Bell's entry has been designated the YAH-63.

Bell is designing and manufacturing two tilt-rotor research aircraft, designated XV-15, under contract to NASA. This craft will be used to assess the applications of tilt-rotor technology to civil and military needs. The primary contact for this facility is Mr. J. F. Joggers, telephone 817-280-3629.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

Bell's current test efforts are directed toward rotary-wing aircraft systems and subsystems. Ballistic vulnerability tests are being conducted on both singular- and multi-vulnerable components.

Helicopter subsystems currently undergoing tests include:

1. Main rotor blades
2. Main rotor retention system
3. Tail boom and fittings
4. Control system
5. Hydraulic cylinders
6. Fuel cells
7. Weapon system and ammo bay
8. Armor.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The Bell helicopter facility has one indoor and two outdoor ballistic test ranges. The indoor range, called the Ballistic Vulnerability Laboratory, is located in the new Engineering Test Building at the main Bell Plant. One outdoor range is located at the Bell Plant (Plant 6) adjacent to the Arlington Municipal Airport. An additional remote outdoor facility is available for HE (high explosive) testing from Jet Research, Incorporated, under contract to BHC.

The Bell outdoor range also serves as a production firing range for testing attack helicopter turreted weapons. The facility is equipped to conduct and record the results of both static and dynamic ballistic vulnerability tests.

The new indoor range became operational in January 1974. It consists of a remotely operated gun range and adjoining control room.

ACCESS

The main Bell Plant is located on Highway 183 in Hurst, TX. The outdoor range (Plant 6) can be reached via McKnight Road to Arlington Airport.

Air transportation is provided by both a heliport at the main plant and Arlington Municipal Airport (2500-foot runway) near Plant 6.

A spur of the Chicago, Rock Island and Pacific Railroad is available at the main plant.

MAINTENANCE/FABRICATION CAPABILITY

The ballistic test facilities have use of the complete Bell plant and laboratory manufacturing and machining capability. Laboratory equipment includes welding apparatus (arc and submerged-arc), metal saws, hydraulic equipment, and vibration facilities. Plant facilities include machining jigs, fixtures, and hardware, joining apparatus, and associated handling equipment.

LOGISTICAL SUPPORT CAPABILITY

The main plant can store ordnance up to Class C. This includes ball rounds to .50 caliber and armor piercing rounds. HE rounds are off-loaded and fired under contract to Bell by Jet Research of Arlington, TX. Jet Research also stores HE and HEI explosive ordnance which is sent to Bell when required. Two 30-inch and one 48-inch storage cabinets are available in the control room.

INDOOR FACILITIES

BALLISTIC VULNERABILITY LABORATORY

Dimensions

The indoor Ballistic Vulnerability Laboratory shown in Figure J-1 consists of a firing tunnel 16- by 51-feet with an attached control and storage room that measure approximately 13- by 28-feet. Fired rounds are captured in a 10-foot-deep sand bunker. Firing distance is adjustable to 25-feet maximum.

Weapons/Projectiles Available

The Ballistic Vulnerability Laboratory has the following barrels available for projectile firing:

1. One 23-mm standard-twist barrel
2. One 23-mm high-twist barrel
3. Two .50 caliber barrels, one smooth-bore, one rifled barrel
4. Two 7.62-mm rifled barrel
5. One 20-mm rifled barrel
6. One .40 caliber smooth-bore barrel.

The Ballistic Vulnerability Laboratory can currently fire 7.62-, 12.7-, 20-, and 23-mm projectiles of all varieties except HE. Forty caliber 23-mm HEI fragment simulators can also be fired. The 7.62- and 12.7-mm projectiles may be fired both aligned and fully tumbled. A tipping plate is used to tumble 7.62-mm projectiles; 12.7-mm projectiles are tumbled by firing through a smooth-bore barrel. All projectiles except HE rounds are off-loaded by Bell personnel to control initial projectile velocities.

Environment

The indoor facility cannot simulate nonambient environmental conditions, but can provide static loads to 100,000 pounds and dynamic loads to ±17,000 pounds to the test specimen.

Live/Inert Fire

No HE, HEI, or flammables can be tested in the indoor facility.

Safety (and Security) Requirements

Special fail-safe locking devices and procedural precautions are employed to ensure the safety of all test personnel. Fired rounds are captured in the 10-foot-deep sand bunker. Warning lights also notify personnel in the area that gunfire testing is in progress. In addition, the complete facility is in a secure area.

The firing range is equipped with a water fire-extinguishing system having a flow capability in excess of 1200 gal/min and a 1500 ft^3/min airflow system to remove gun gases.

Power Availability

The range contains two lines of 440 VAC and four lines of 110V, 115A electrical power. Hydraulic flow of 30 gal/min at 3000 lb/in^2 is also available.

Observation/Communication

A 1.5- by 1.5-foot ballistic glass viewing window (Figure J-1) is available to monitor tests. This window is used *only if required*. A telephone is located in the Laboratory control room.

In-flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Initial projectile velocities are recorded using a B-Square Manufacturing Co., chronograph (500 to 4000 ft/sec, ±2%); residual velocities are calculated using a Celotex fragment capturing system or high-speed photography. Motion picture capabilities range from 24- to 10,000-frames/sec. The Bell Photography Laboratory provides black and white and color still documentary photography. Turnaround time for photography is usually 24 to 48 hours.

TIMING. A master sequencing console with six switching circuits is being constructed for use in the Ballistic Vulnerability Laboratory. This will provide selectable sequencing intervals for camera start, counter start, weapon arm, camera stop, counter stop, etc.

Pulse generators are also available to provide film timing. Timing lights are driven to 10, 100, or 1000 pulses/sec to imprint timing mark directly on the motion picture film.

TELEMETRY. An 18-channel hardwired telemetry cable is presently available in the instrumentation conduit. The majority of the inputs are gun functions and terminal ballistic data.

OTHER. The instrumentation facilities available at the Bell plant can accommodate many data acquisition requirements. Instrumentation systems are setup and tailored to specific test requirements. In most cases, only a simple build-up or modification of existing instrumentation will be sufficient. Unique capabilities, cable buildups, and transducer installations can also be accommodated.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photographic instrumentation consists of:

1. Fastex high-speed cameras to 1000 frames/sec
2. Hycam high-speed cameras to 11,000 frames/sec
3. Frame splitter for Hycam cameras
4. Various slow speed cameras of 24 to 28 frames/sec

TIMING. Pulse generators are available to provide film timing. Timing lights are driven at 10,000 and 1000 pulses/sec and imprint timing marks directly on the film.

TELEMETRY. The hardwired telemetry cable connects transducers on the test specimen to the Data Acquisition Station. Typical parameters include:

1. Pressures to 10,000 lb/in^2
2. Loads to 100,000 pounds
3. Shock to 5000 pounds
4. Temperatures from -250°F to excess of 2000°F
5. Flow rates to 60 gal/min (Hydraulic).

OTHER. Other instrumentation includes:

Chronographs:	B-Square Manufacturing Co.	500 to 4000 ft/sec
1-screen penetration record		
1-light interrupting record		
Optical Micrometer	300X Magnifier	0.005 inch increments
Eddy Current Crack Follower	MTS, Minneapolis, MT	
Magnetline Examination		0.001 inch increments
Zieglo Examination		0.001 inch increments

Environmental Simulation and Measurement

Static loads to 100,000 pounds and dynamic loads to ±17,000 pounds can be applied to the test specimen.

Planned Expansion/Modification

A control console containing counters, code generators, digital readouts, switching circuits, and fire control panel is being installed in the control room.

Bell is also awaiting delivery of a 14.5-mm barrel to use with GFE 14.5-mm ammunition.

OUTDOOR FACILITIES

BELL OUTDOOR RANGE

Dimensions

The Bell outdoor range consists of a firing stand and target butt. Projectiles are fired from an open air location into a concrete tunnel approximately 30 feet deep. Maximum firing range is 20 feet.

Weapons/Projectiles Available

All weapons available in the Bell Vulnerability Laboratory can be fired on the outdoor range. In addition, flammable targets can be ballistically tested. The weapons can either be rigidly mounted on a concrete firing pad or fired from aircraft positioned on the range. Production firing of attack helicopter turreted weapons is performed on the outdoor range. HE and HEI rounds cannot be tested on this range.

Environment

The facility is equipped to conduct both static and dynamic loading of test specimen.

Live/Inert Fire

The outdoor range can accommodate tests with inert ordnance, fuel, and flammables. Tests involving firing into fuel cells are performed on this range.

Safety (and Security) Requirements

The entire outdoor range is located in a secure area. A concrete barricade provides a safe location for test personnel to remotely fire the gun and witness the tests. Additional safety equipment includes a flashing light indicating a test in progress and a signal horn to warn of an impending test firing.

Rounds are captured by a steel plate positioned at a 45-degree-angle and a high-flow water spray and capture tank.

Power Availability

Electrical power (110 VAC and 440 VAC) is available for instrumentation and control. Portable generators and hydraulic carts are also used to provide static and dynamic loading.

Observation/Communication

Visual observation of tests is possible using barricades located at a safe distance behind the gun stand.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photo data is obtained from high-speed cameras (Fastex and Hycam). Photography is also used extensively to monitor projectile flight characteristics.

TIMING. Time reference is provided by pulse generators. Time-sequencing can also be provided by preset counters. Other timing references are available as required from plant laboratory facilities.

TELEMETRY. The majority of the instrumentation is for terminal ballistic data.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed to 11,000 frames/sec Fastex and Hycam cameras and low-speed (24 frames/sec) cameras are used extensively to gather data and document tests.

TIMING. Time reference is provided by pulse generators and preset counters. Other timing references are available from plant laboratory facilities.

TELEMETRY. Standard laboratory transducers are available for:

1. Pressures to 10,000 lb/in^2
2. Shock to 5000 pounds
3. Loads to 100,000 pounds
4. Temperature from -250°F to in excess of 2000°F.

The instrumentation used at this facility is usually configured to support specific data requirements.

Environmental Simulation and Measurement

Static loads to 100,000 pounds and dynamic loads to ±17,000 pounds can be provided to the test specimen.

Planned Expansion/Modification

The proposed acquisition of a 14.55-mm gun will provide additional capability to the outdoor range. Increased firing of fragments is also planned. A continued study of training methods and ballistic testing techniques is underway.

REMOTE TEST FACILITY

A small uninstrumented open-air pit is available for HE and fuel cell testing from Jet Research, Inc., under contract to Bell. Permanent facilities are to be constructed in the near future to accommodate HEI testing of components and subsystems. Maximum firing range from weapon to fuel cell is approximately 100 yards.

TEMPORARY TEST FACILITY

The Bell Ballistic Laboratory can temporarily locate firing mechanisms to satisfy specific requirements. As an example, projectiles have been fired into a transmission cell to study the vulnerability of the transmission system under torque and load. The weapon was temporarily placed on the roof of the cell and fired downward into the transmission. Such installations are temporary and are designed as needed.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Ballistic vulnerability data is stored on film, magnetic tape, and oscillograph hardcopy. Photographic records of each test are kept and filed by test number. The outdoor range can provide transformation and analysis of data using the Plant 6 Data Center if required

QUICK-LOOK CAPABILITIES

Oscillograph hardcopy, digital counters, and oscilloscopes provide quick-look data for most ballistic vulnerability tests. Photographic data (Polaroid) is also obtained when required.

PROCESSING

The Laboratory Data Center has a digital data system containing a Texas Instruments Model 960A mini-computer, Remex Casette tape recorder and associated signal conditioning equipment. This system is not presently utilized for ballistic vulnerability data reduction.

DISTRIBUTION

Photography turnaround time is usually 24 hours. Formatted data usually requires 24 to 48 hours. Most vulnerability data is manually processed from photographs and oscillograph hardcopy.

DISPLAYS

Oscilloscopes, digital counter and oscillographs provide data display.

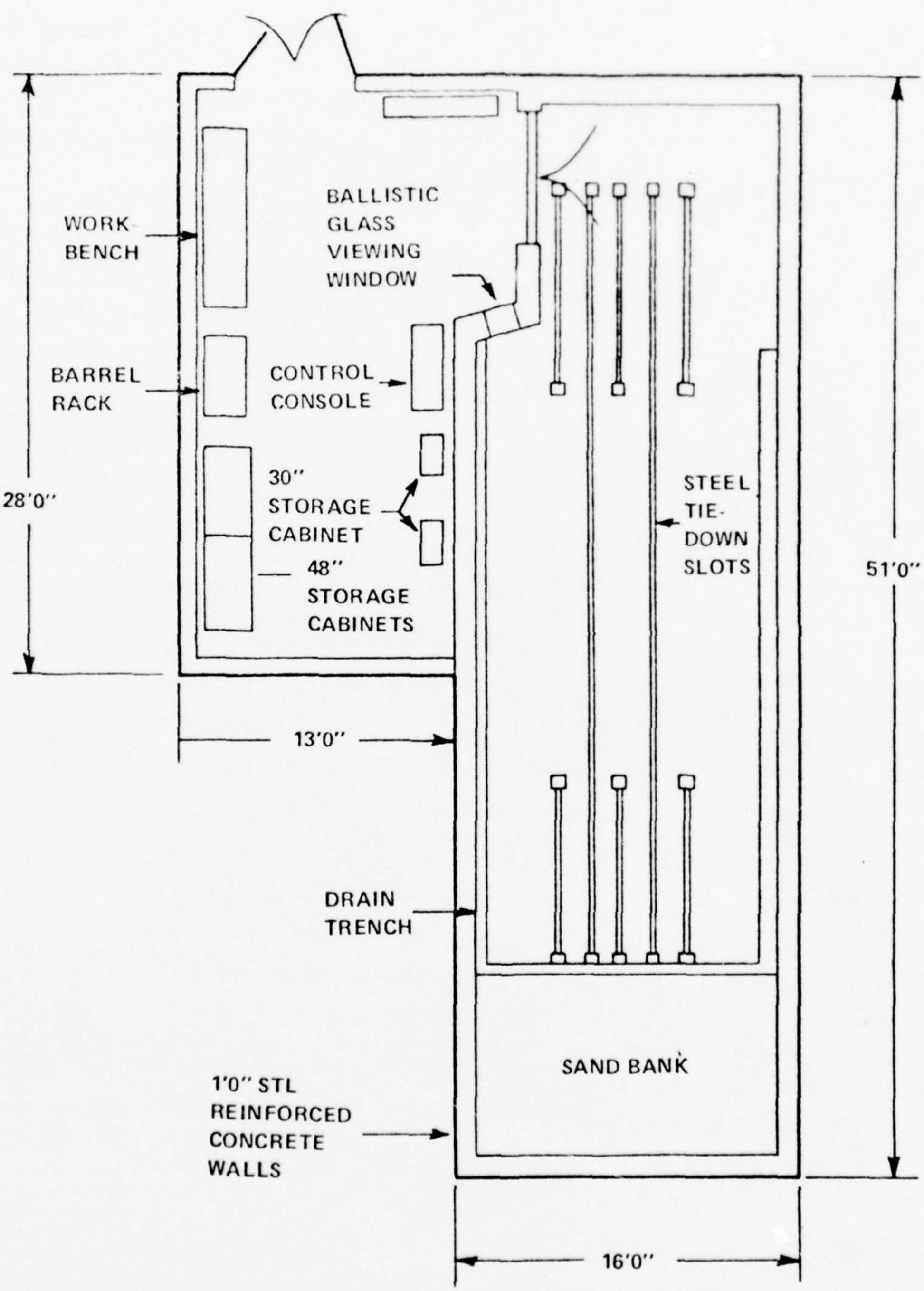


Figure J-1. BHC Indoor Ballistics Laboratory.

ANNEX K - INTRODUCTION

OVERVIEW

General Dynamic's Convair Aerospace Division has three major plants (one Air Force Plant) and four specialized test sites in the San Diego area. These facilities cover more than 10,000 acres, with 6.1 million-square-feet under roof, and employ approximately 8000 personnel.

The Convair Aerospace Division is manufacturing the DC-10 fuselage, Space Shuttle mid-fuselage, Atlas and Centaur booster rockets, and the NASA Space Tug (modified Centaur).

The division has established a centralized area for composition material activities in the Kearny Mesa Plant. The Convair Aerospace Ballistic Test Facility, shown in Figure K-1, is located in the Kearny Plant and is used to develop and evaluate lightweight armor materials and to study the behavior of materials and structures when subjected to gunfire damage under service condition.

Convair has extensive and well-equipped metallurgical, plastics, heat treatment, metal processing, mechanical property testing and metallographic laboratories capable of supporting armor and structural materials evaluation, development and research programs. The primary contact for this facility is Mr. Mel Campbell, telephone 714-277-8900.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

Conviar has conducted studies correlating ballistic damage characteristics of structural and armor materials with their fracture mechanics properties, strength and micro-structure.

The Ballistic Test Facility has supported Convair Aerospace studies of ballistic effects on materials, involving both structural and armor materials. Materials studied include aluminum, titanium and steel alloys, titanium honeycombs, fiber-reinforced composites, and structural armors. Bolt-on integral, and semi-integral armor has also been evaluated.

SURVIVABILITY/VULNERABILITY FACILTIES OVERVIEW

The Ballistic Test Facility is within a reinforced concrete walled area, located within walking distance of other laboratory areas used by operating personnel. All projectiles are launched into a fire control tube that contains a blast suppressor and velocity timing ports.

The forced-air ventilated target box may be cut and reassembled to straddle the larger target specimens. All instrumentation and controls are located in an external control room from which the tests are conducted.

ACCESS

The facility, located in the San Diego area, has access to all modes of transportation, including an on-plant railroad spur.

MAINTENANCE/FABRICATION CAPABILITY

The Kearny Plant has complete machine shops for fabricating test specimens and fixtures in addition to production shop facilities capable of fabricating complete space vehicles. Available, too, is the equipment necessary to machine, join and finish specimens, including full-scale structures, composed of the most advanced aerospace materials.

LOGISTICAL SUPPORT CAPABILITY

Extensive shop, storage, and laboratory support facilities are available in the Convair San Diego Facilities.

Cartridge loading facilities for standard rounds up to and including .50 caliber are available. Storage is available for .22-, .30-, and .50-caliber, 8-mm AP, 14.5-mm, and 20-mm ball, AP, API, APIT, and HE ammunition.

INDOOR FACILITIES

BALLISTIC TEST FACILITY

Dimensions

The Ballistic Test Facility consists of a gun mount, a 30-foot enclosed flightpath, and an enclosed 6 by 6 by 14-foot target area. The target box is made of 1/2-inch steel plates lined with plywood and sandbags, and is backed up by a 45-degree replaceable steel plate backstop. The box is fitted with a 5-foot door and a removable top for access to the target area. The entire range is a 4000-ft^2 reinforced concrete building. The target box will accommodate test specimens up to 6 by 6 by 8-feet in size. Specimens up to 25-feet-wide can be handled by the facility.

The standard firing range is approximately 40 feet. A maximum firing distance of 100 feet can be provided.

Weapons/Projectiles Available

Smooth-bore and rifled guns of .22-, .30-, and .50-caliber, 8-, 14.5-, and 20-mm AP, API, and ball ammunition are available. Heavy duty loading equipment is available for disassembling and reassembling standard ammunition.

Environment

The range has fixtures available to load sheet, plate, tube, rod, or composite specimens in tension, compression, torsion, or shear, and to support to obtain the desired angle of obliquity. A 415,000-pound capacity hydraulic ram is available for testing simulated aircraft structural members under service loads.

Artificial atmospheres of inert gases and vacuum can be provided. Specimens can also be temperature treated during testing to simulate climatic environments.

Live/Inert Fire

Inert projectiles up to 20-mm are fired in the indoor facility.

Safety (and Security) Requirements

Electrically activated firing mechanisms allow complete control of the firing with safety interlocks. Warnings are automatically activated at various steps of the arming process and the test cannot be initiated until all safety criteria are met (target box latched, all personnel accounted for, and warnings sounded, audio and visual).

All firings are into the fire control tube which contains a blast suppressor to eliminate and dissipate muzzle blast. In addition, the sand-filled target box back panel is capable of stopping a .50-caliber AP projectile in 8 inches at service velocity. This is backed by 2 inches of armor steel.

Power Availability

Electrical and mechanical power in the Ballistic Test Facility include 110, 220, 440, and 600 VAC, compressed air at 120 lb/in^2 and hydraulic pressure to 15,000 lb/in^2.

Observation/Communication

The instrumentation and control room provides visual, intercom, and headphone contact with the test area during set-up.

During tests, all personnel are located in the control room.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Extensive facilities for motion picture coverage are available to the Ballistic Test Facility. Cameras available in addition to standard 16- and 35-mm models include:

1. Fastex Model WF-3, 100 msec at 7000 frames/sec
2. Fastex Model WF-4, 1.0 second at 8000 frames/sec
3. Dynafax Model 326-2, 224 frames at 25,600 frames/sec

4. Beckman & Whitley Model 192, 30 frames at 1.2×10^6 frames/sec
5. Abtronics Model 3, four frames at 1×10^8 frames/sec.

Bullet velocities are generally measured in the middle 10 feet of the 30-foot flight tube using breakwires and photoelectric screens. Projectile velocities as high as 3500 ft/sec have been measured. If the bullet is to be tipped before target impact, counter triggers can be placed at any point between tipping plates and the target.

TIMING. Microsecond counters, triggered by photoelectric screens, are used to measure projectile velocities.

TELEMETRY. All transducers are used to gather terminal ballistic data.

OTHER. Bore-sighting is accomplished using a small helium-mean laser and a sample slit system. This sytem clearly defines the impact area before each firing.

Projectile yaw and fragment scatter patterns are determined by witness plates (thin sheets of paper that retain the profiles of projectiles that pass through them).

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The high-speed cameras are also used to record projectile/specimen impact data.

TIMING. Pulse generators and counters are used to provide data time correlation. Timing pulses are recorded on magnetic tape and film for subsequent reduction by the Convair Data Center.

TELEMETRY. All transducers are hardwired to the instrumentation and control room for recording and observation. Transducers available include:

1. Loads to 1,000,000 pounds
2. Accelerations to ±20,000 g's
3. Temperatures from -460°F to 5000°F
4. Pressures as required
5. Impact velocities (with photoelectric screens) in excess of 25,000 ft/sec.

OTHER. Additional capabilities of this facility include crack length propagation (using accoustical emission and other standard fracture mechanism techniques), obliquity of projectile path, residual strength results, and specimen elongation.

Specialized instrumentation systems can be built-up, if required, using Convair facilities.

Environmental Simulation and Measurement

Gaseous atmospheres can be provided. Atmospheric pressures from vacuum to normal atmospheres are also possible. Also, a 415,000 pound capacity hydraulic ram is used to provide loads to test specimens.

Heat lamps and cryogenics make temperatures of -320°F to in excess of 2000°F possible.

Planned Expansion/Modification

The facility will be modified to accommodate workloads.

OUTDOOR FACILITIES

SYCAMORE SITE

Dimensions

The Sycamore Site, a 2400-acre, uninstrumented range, is also used for ballistic tests. The site is abandoned except when used for tests. Normal firing range is 50- to 100-feet. Ranges as great as 3/4-mile are possible.

The Sycamore Site is used for testing involving large quantities of combustible material.

Weapons/Projectiles Available

Weapons as large as 23-mm have been fired at the facility.

Environment

Tests are run at ambient conditions only.

Live/Inert Fire

Inert, HE and HEI projectiles can be fired at the facility.

Safety (and Security) Requirements

Remoteness of the site and standard safety and security procedures provide a safe working area.

Power Availability

Standard 110 VAC lines are available.

Observation/Communication

Visual observation is possible at safe distances from tests. No site communications are available.

Instrumentation

All instrumentation for the remote site is borrowed from the indoor test range as needed. No instrumentation is permanently located at the site.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data is stored on magnetic tape, oscillograph hardcopy, and film.

QUICK-LOOK CAPABILITIES

Oscilloscope traces photographed by poloroid cameras, digital counters, and strip chart recorders are used to provide quick-look data.

PROCESSING

System and Model

The Convair Aerospace Computer Complex is used for digital data reduction of the ballistic data. The facility has a CYBER 72 system with 97,000 sixty-bit word capacity.

The large computer is backed up by a CDC-1600 and several versions of the IBM 360 family of machines. In addition, the SDS 930 digital computer and three COMCOR Ci analog consoles have been interconnected and interfaced to support scientific and engineering programs requiring digital and analog data.

Language

FORTRAN is used with this system.

Input/Output Options

Input/output may be accomplished by card reader, teletype, magnetic tape recorder, light pencil, and CRT.

DISTRIBUTION

Maximum turnaround time for digital data is approximately 4 hours.

Photographic turnaround times are 6 hours for negatives and 18 hours for prints.

DISPLAYS

Digital counters, CRT's, oscillographs, and oscilloscopes provide data display.

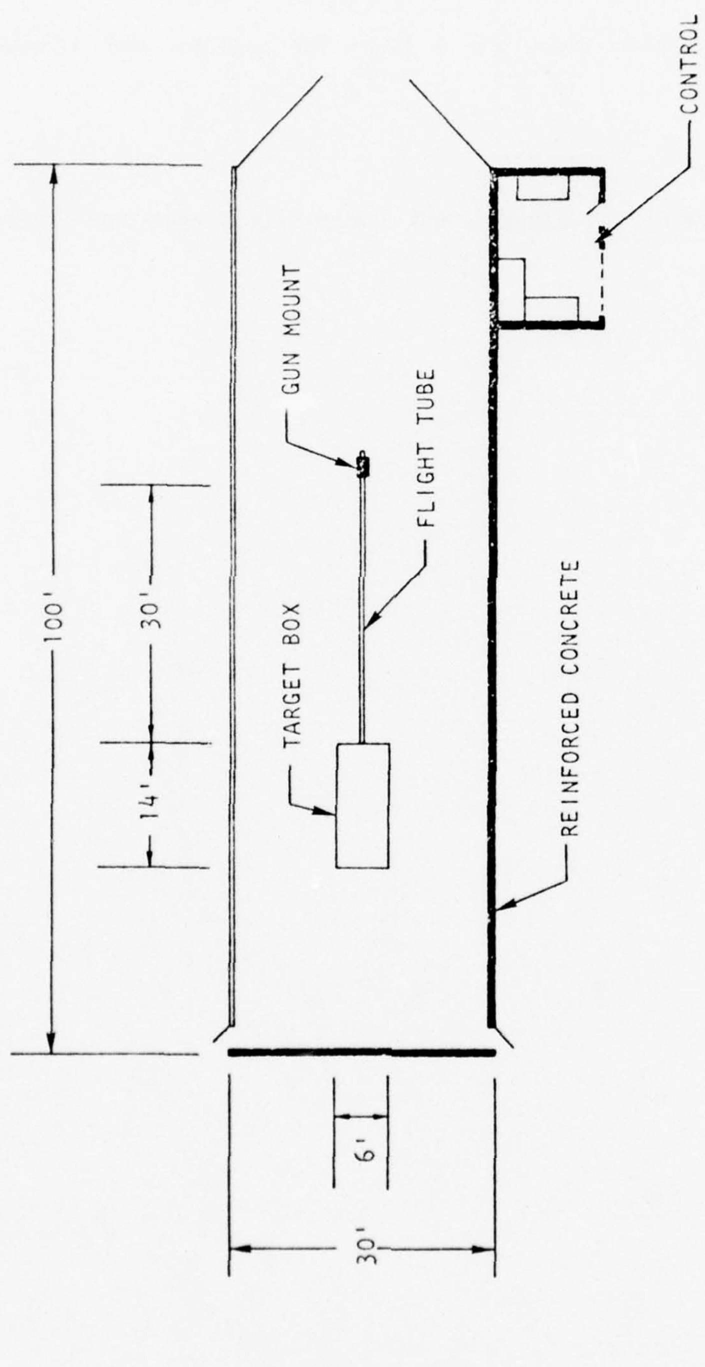


Figure K-1. Convair Aerospace Ballistic Test Facility.

ANNEX L - INTRODUCTION

OVERVIEW

FMC's Ordnance Engineering Division is located in San Jose, CA. The divisions engineering and support facilities occupy over 65,000 ft^2 of floor space in a complex of single-story, air-conditioned buildings. The experimental shop facilities occupy approximately 70,000 ft^2 of floor space. The facility employs approximately 2600 personnel in the San Jose area.

The San Jose Ordnance Plant was established for volume production of tracked military vehicles and contains all operations required for low-cost production. Vehicles developed by FMC includes the MRMU (Mobile Remote Manipulating Unit), the High Mobility Vehcile XR311, the M113 Family of Vehicles and the LVTP7 Family of Vehicles. Defense Department contracts in munitions research and development includes:

1. Maverick missile warhead (subcontractor to Hughes Aircraft)
2. Aim 4-H missile warhead (subcontractor to Hughes Aircraft)
3. Artillery Dispersal System
4. Signal Smoke, guided missile (subcontractor to General Dynamics)
5. SUU-51B/B Munitions Dispenser
6. Fragmentation - incendiary shaped-charge warhead.

The facility has the diversified capabilities required for performance and qualification testing of vehciles, vehicular assemblies, components, and materials. The primary contact for this facility is Mr. D. R. Kennedy, telephone 408-289-2777.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

FMC Ordnance Engineering has been heavily involved in survivability testing of low-altitude aircraft systems and subsystems. The Terminal Ballistic Department has also performed research and development in the areas of:

1. Determination of the armor protection potential of materials such as ceramics, dual hardness steel, plastics, magnesium, titanium and various composite materials.

2. Practical application of armor material to armored vehicles, helicopter seats, ballistic doors for aircraft shelters, ballistic shielding for civilian police agencies, and other applications.

3. Developing manufacturing procedures and techniques for new armor materials such as dual hardness, heat-treatable steel armor and magnesium armor.

4. Upgrading armored vehicle protection levels such as product improvements to the M113 Armored Personnel Carrier to improve protection against mine damage and HEAT rounds.

The department fabricates candidate armor systems, ballistically tests them, and provides data to design groups.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The Terminal Ballistics Department has three test ranges as shown in Figure L-1. The indoor Terminal Ballistics Range, located adjacent to FMC's San Jose manufacturing facility is utilized for testing armor with various U.S. and foreign projectiles. This facility is patterned after the Government's Aberdeen Proving Ground range and was sanctioned by the Government to perform ballistic qualification tests for military production programs when the Aberdeen Proving Ground facility had a large backlog of ballistic tests. FMC has two remote test sites for large-scale static detonations, ballistic firings, and HE loading. These test sites are located near Hollister, CA, approximately 70 minutes driving time from the Santa Clara office. Site 1, located on FMC mining property, Dolomite Quarry, is used for firing of fragmentation, pyrotechnique, and incendiary devices. A specially constructed firing arena, adjacent to the quarry, has been used for a wide variety of munitions tests. A short-trajectory range is available for testing HEAT ammunition fired from recoilless rifles against armor plate and for test firing up to 90-mm cannon ammunition. Site 1 has an explosive detonation limit of 1000 pounds. Site 2 (Hollister Facility) was developed to increase the ordnance testing capabilities of FMC. The facility has an explosive detonation limit of 150 pounds.

ACCESS

The San Jose Facility can be reached via De La Cruz Boulevard and Coleman Avenue off of U.S. Highway 101 or Interstate Highway 17. A spur of the Southern Pacific Railroad is available on-site. Port facilities are available at nearby San Francisco Bay, and air transportation is supplied by the San Jose Airport, adjacent to the FMC facility.

The remote ranges can be reached via Highway 101 south from the San Jose Facility to Hollister, CA.

MAINTENANCE/FABRICATION CAPABILITY

The San Jose Ordnance plant has extensive production facilities available for build-up and testing of ballistic test specimens. Shop facilities include an aluminum and steel fabrication shop, plate preparation equipment, welding equipment, machining equipment, heat treating equipment, and a machine tooling shop.

LOGISTICAL/SUPPORT CAPABILITY

A FMC designed universal weapon receiver is used to mount ten different caliber test barrels.

Projectiles of various types, including fragment simulators, may be fired. Powder balances and hand loading equipment are available for ammunition reloading to carefully control projectile velocity.

In addition to 260,000 ft^2 of material storage area, (60,000 under roof, the plant has 40,000 ft^2 of office space, 40,000 ft^2 of final processing and checkout space, and 350,000 ft^2 of storage and shipping space).

The Hollister facility has explosive storage facilities with a capacity in excess of 100,000 pounds of all classes of explosives.

INDOOR FACILITIES

INDOOR TERMINAL BALLISTIC RANGE

Dimensions

The Indoor Terminal Ballistic Range, located at the San Jose Facility, is 45 by 10 feet with two impact chambers. One impact chamber is 3 by 3 by 3 feet and is used for testing small armor samples. The second impact chamber is 10-feet-high, 10-feet-deep, and 16-feet-wide and is used for larger samples. Maximum firing distance is 25 feet.

Weapons/Projectiles Available

Table L-1 lists the weapons available in the ordnance division's permanent inventory. The indoor range can accommodate all of the weapons listed.

Environment

No simulated environments are available.

Live/Inert Fire

The indoor range can accept live nonexplosive warheads.

Safety (and Security) Requirements

The facility meets all of the DoD requirements for ballistic test facility safety and security. All explosive loading, assembly, disassembly, and testing operations are carried out per safety SOP's to assure safe operations.

Power Availability

Electrical lines of 110-, 220-, and 440-VAC are available.

Observation/Communication

Hardwired intercom stations provide communication between the control room, instrumentation, and test area.

In-Flight Ballistic Instrumentation

All instrumentation, except for velocity measuring chronographs, is used to measure terminal ballistic data.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photographic support equipment available at the facility includes:

1. Movie Cameras

   2 Hycam high-speed cameras, 16-mm

   1 Arriflex motion picture documentary camera, 16-mm

   1 Milliken intermittent camera, 16-mm

   1 Bell & Howell camera, 16-mm

2. Still Cameras

   3 Nikkon 35-mm, one with automatic film advance mechanism

   1 Speed Graphic, 4 by 5

   1 View Camera, 4 by 5.

A flash radiograph system is used to obtain projectile/specimen impact data.

TIMING. Pulse generators and digital counters provide data time correlation.

TELEMETRY. All transducers are hardwired to the data acquisition system. Typical transducers used to measure terminal ballistic data include:

1. Loads to 100,000 lb/max
2. Pressure to 100,000 lb/in^2
3. Temperature from -200°C to +1000°C
4. Impact velocity to 4000 ft/sec
5. Acceleration to ±5000 *g*.

OTHER. The following equipment was developed to support ballistic testing.

1. Ultrasonics
2. Hardness Tester
3. Impact Tester
4. Metallography
5. Chemical Analysis

Environmental Simulation and Measurement

No environmental simulation available at this facility.

Planned Expansion/Modification

No facility changes are currently planned.

OUTDOOR FACILITIES

SITE 1 (Dolomite Quarry)

Dimensions

Site 1 has a large dolomite quarry (1200 feet across and 200 feet deep), which forms an arena for firing of explosive, incendiary, and fragmentation rounds. Maximum firing range is 100 yards. A specially constructed firing arena, adjacent to the quarry has been used for a wide variety of munitions tests. A short-trajectory range is available for testing HEAT ammunition fired from recoilless rifles against armor plate and for test firing up to 90-mm cannon ammunition.

Weapons/Projectiles Available

All weapons/projectiles listed in Table L-1 can be fired at Site 1.

Environment

No simulated environments are available.

Live/Inert Fire

Site 1 has an explosive detonation limit of 1000 pounds.

Safety (and Security) Requirements

The area forest ranger is notified before each test. A courtesy call to the sheriff's office is also made.

A public address system, radios, and lights are used to warn personnel in the area of an upcoming test.

Power Availability

Commercial lines provide 110-, 220- and 440 VAC electrical power. Portable equipment provides hydraulic power at the site.

Observation/Communication

Visual observation from behind protection barricades is available. Telephones, 2-way radios, and a public address system provide site communications.

In-Flight Ballistic Instrumentation

Only terminal ballistic instrumentation is available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed movie cameras provide projectile flight and impact. High-speed cameras available are:

1. Hycam 16-mm movie camera
2. Arriflex 16-mm motion picture documentary camera
3. Milliken 16-mm intermittent camera
4. Bell & Howell 16-mm movie camera

TIMING. Digital counters and pulse generators are used as time reference.

TELEMETRY. All transducers, strain gages, pressure gages, accelerometers and thermocouples, are hardwired to blockhouse instrumentation.

1. Loads to 100,000 lb/max
2. Pressure to 100,000 lb/in^2
3. Temperature from -200°C to +1000°C
4. Impact velocity to 40,000 ft/sec
5. Accelerations to ±5000 *g*.

Environmental Simulation and Measurement

No nonambient environments are available.

Planned Expansion/Modification

No expansions or modifications are currently planned.

SITE 2 (Hollister Facility)

Dimensions

Site 2 contains 1200 acres and has:

1. Field test support shop and inert operations building

2. Explosive storage magazine area

3. Explosive and hazardous processing (melt and press loading, incendiary and pyrotechnic loading) building

4. X-ray inspection

5. Explosive and hazardous assembly buildings

6. Munitions test arenas and sites.

The explosive-melt loading building is equipped with the latest 30-gallon vacuum-melt kettle, two 5-quart kettles, and all utilities required to permit high quality casting of all types of military HE. The explosive-melt equipment can be remotely operated when required.

The primary terminal ballistics test arena provides 360-degree natural terrain protection and can accommodate explosive ordnance detonations up to 150 pounds of HE.

The maximum nominal firing range is 100 yards; however, depending upon safety factors, weapons can be fired at ranges up to 1000 yards.

Weapons/Projectiles Available

The facility can accommodate all the weapons shown in Table L-1 and associated ammunition.

Environment

No simulated environments are available.

Live/Inert Fire

The facility can handle all classes of ammunition and explosives. The facility explosion detonation limit is 150 pounds.

Safety (and Security) Requirements

The area forest ranger is notified before each test. A courtesy call to the sheriff's office is also made.

A public address system, radios, and lights are used to warn personnel in the area of an upcoming test.

Power Availability

Commercial lines provide 110-, 220-, and 440-VAC electrical equipment. Portable hydraulic equipment is also available.

Observation/Communication

Dual periscopes, located in the site blockhouse, and a portable camera/video recorder system are used to observe tests.

Telephones, 2-way radios, and a public address system provide site communications.

In-Flight Ballistic Instrumentation

Only terminal ballistic and explosive detonation instrumentation are available.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Remotely actuated, high-speed cameras are used to provide test information.

A remote-generated 325-kV x-ray facility is provided to permit the radiographic inspection of both inert and HE-loaded ordnance.

TIMING. Digital timing and pulse generators are used for time correlation.

TELEMETRY. The arena floor has a permanent underground network of conduits and armored outlet boxes for instrumentation and firing leads. The conduits terminate at a large subterranean firing bunker which protects all electronic recording devices, test personnel, and observers.

Transducers available include:

1. Loads to 100,000 lb/max
2. Pressure to 100,000 lb/in^2/max
3. Temperature from -200°C to 1000°C
4. Impact velocity to 40,000 ft/sec
5. Accelerations to ±5000 *g*.

OTHER. The following equipment is used to support tests at Site 1 and Site 2.

1. 2 High-voltage firing units
   1 Beckman Whitley
   1 FMC manufacturer
2. 2 Oscilloscopes, Tektronix Model 543 and camera

3. 1 Oscilloscope, Tektronix Model 545 and camera
4. 1 Dual beam oscilloscope, Tektronix Model 556 and camera
5. 1 Transistor tester, Tektronix Model 575
6. 1 Counter, interval, General Radio, digital to 10 MHz
7. 1 Counter, Berkeley, to 1 MHz
8. 2 Dual delay units, Altronic, to 10 msec
9. 1 Wave function generator oscillator, Hewlett-Packard
10. 1 Velocity measuring device, Avtron, with photoelectric screens
11. 1 12-channel temperature recorder, Leeds and Northrup
12. 6 Power supplies 12 to 500 volts
13. 1 Frequency standard, 1 MHz (maintained in calibration)
14. 6 Pressure transducers, Kistler Model 603L
15. 4 Preamplifiers, Kistler Model 504
16. Oscilloscope preamps, Tektronix.

Environmental *Simulation* and Measurement

No nonambient environments are available.

Planned Expansion/Modification

No expansions or modifications are currently planned.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data is stored on film and hardcopy.

QUICK-LOOK CAPABILITIES

Oscilloscopes, counters, and photographs provide quick-look data.

PROCESSING

System and Model

The San Jose plant is equipped with two IBM 2922 remote time-sharing terminals. These are connected to an IBM 370/148 computer with 1.5 megabits of memory at the FMC National Data Center in Indianapolis, IN., by a private telephone network.

Language

1. FORTRAN
2. COBOL
3. PL1

Input/Output Options

The following devices are available for input/output:

1. Card Reader
2. Card Punch
3. 600 Line/min (LPM) Printer
4. 1000 Line/min (LPM) Printer.

The 600 LPM printer is on one of the IBM 2922 terminals. The 1000 LPM terminal is on the other.

Realtime/Interaction

Not applicable to this facility.

DISTRIBUTION

Turnaround time for all film is usually less than 24 hours. Black and white film is developed in-house. Color film is developed by a Kodak facility located nearby.

Turnaround time for other data is usually 24 hours or less depending upon the amount of data required.

DISPLAYS

Oscilloscopes, counters, and a stop motion projector provide data display.

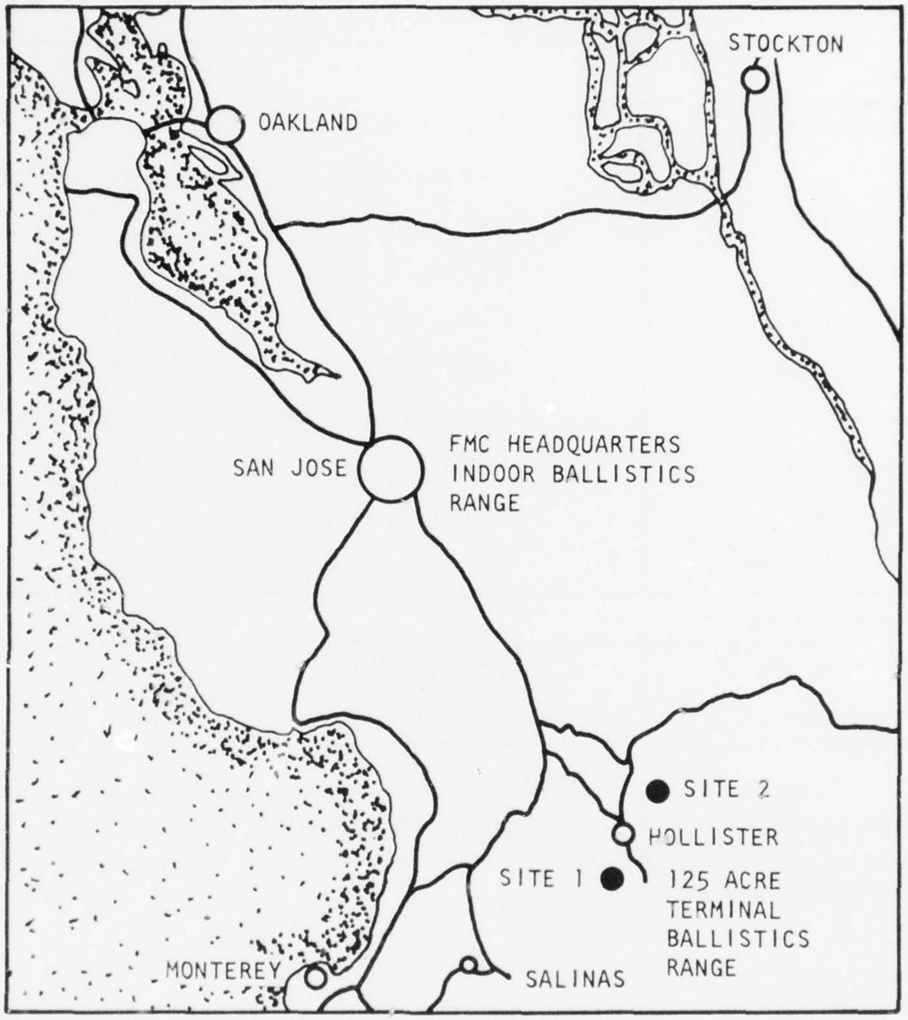


Figure L-1. FMC Corporation Ballistics Department Facilities.

Table L-1. FMC Inventorial Weapons.[a]

United States	
M16A1 (5.56-mm)	7.62-mm MG (machine gun)
AR 15	40-mm, 203 GL (grenade launcher)
M60, M60D MG	60-mm -4 shot XM202 GL
M73E1 MG	M72 GL
.30 caliber MG	25-mm GL
M820 MG (20-mm)	M20-A1-B1 35-mm rocket launcher
M60A1	Mortars (81-mm - M23A1, 4.2 in. M30)
.45 caliber MG	TRW 6425 (25-mm MG)
.50 caliber MG	M18A1 (57-mm)
RH202 (20-mm MG)	
Royal Netherlands Army	
7.62-mm MG (M219)	7.62-mm rifle
7.62-mm pistol	9-mm pistol
U.S.S.R.	**Swiss**
14.5-mm (anti-tank)	20-mm Lathi (anti-tank)

[a]Ammunition available for the above weapons.

ANNEX M - INTRODUCTION

OVERVIEW

The San Juan Capistrano Test Facility, constructed by the Aeronutronic Division of the Philco-Ford Corporation, is an 879 acre site located 10 miles east of San Juan Capistrano, CA, and approximately 35 miles from the Philco-Fort Newport Beach Facility. The test facilities include a Weapon Test Building, (Gun Ranges 1 and 2), with a separate Ready Ammo Storage Building, 1000 Meter Range, Turret Test Building, General Purpose Building with Helicopter Pad, Ammo Storage Facilities, and the required water, fire, and security protection facilities. Figure M-1 shows the test facility layout. In addition to the ordnance test facilities outlined herein, the test site includes an extensive thermostructural test area. The primary contract for this facility is Mr. Ken Nelson, telephone 714-640-1500, ext. 1832.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The primary function of the site is to facilitate weapons and ordnance development. Major test programs include:

1. Gun development firings
2. Propellant formulation/optimization firings
3. HEI fuze tests
4. Gun system environmental qualification
5. Projectile penetration, dispersion and time-of-flight tests.

However, the facility is well equipped to do S/V (survivability/vulnerability) testing and has accommodated such testing in the past.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The ballistic test facilities available at the site include:

1. Weapon Test Building with Gun Range No. 1 (eight firing bays) and Gun Range No. 2 (four firing bays).

2. Turret Test Building that can be used to operate in simulated helicopter firing modes.

3. 1000 meter test range.

4. Special open S/V test site.

5. Environmental test equipment to provide controlled specimen environment.

ACCESS

The Capistrano facility is located 10 miles east of San Juan Capistrano between Highway 74 and Interstate Highway 5. Marine Corps Base, Camp Pendleton, is located 3 miles southeast of the facility. The Newport Beach Plant with air, sea, and rail access is approximately 35 miles away.

A helicopter pad is located east of the General Purpose Shop building indicated on Figure M-1.

MAINTENANCE/FABRICATION CAPABILITY

The 3200 ft^2 general purpose building is designed to provide shop, laboratory, and office space. The building has an over-hanging roof area adjacent to the shop to provide a sheltered work area for helicopter fitting of armament systems

The 1600 ft^2 shop area contains machine tools and sheet metal tools for minor rework and repair of weapons, test fixtures, and system installations.

LOGISTICAL SUPPORT CAPABILITY

The primary Ammunition Storage Building has 3000 ft^2 of storage area. This provides a capability of storage up to 250,000 rounds of ammunition.

An underground HE (high explosive) (Class A) magazine provides 290 ft^2 of storage area for storing up to 10,000 pounds of HE.

The Ready Ammunition Storage Building, adjacent to the Weapon Test Building, can store up to 10,000 rounds of ammunition at constant temperature.

Office space, security and first aid facilities are also available at the site.

INDOOR FACILITIES

GUN RANGES NO. 1 AND NO. 2

Dimensions

Gun Range No. 1 is the original ordnance test complex consisting of eight bays, two groups of four each opposed. Table M-1 gives the dimensions of each bay located on Range No. 1. The eight bays are supported by one common control and data acquisition room. Gun bays W1-W4 each have a firing maximum range of 270 meters. Gun Bays E1 through E4 have a firing range of 250 meters.

Gun Bays E5 through E8 (Figure M-1) of Gun Range No. 2 were added in 1973 to provide a facility for test of large, high energy gun systems. Each bay has a maximum firing range of 250 meters. Table M-2 shows the dimensions of each Range No. 2 bay. Each pair of bays is supported by a separate control and data acquisition room.

All ranges are actually outside, but the gun mounts are inside and environmentally protected.

Each Range No. 2 bay has built-in noise capability, hydraulic power, plumbing and TV surveillance.

Weapons/Projectiles Available

Range No. 1 bays were built to support a variety of caliber systems of low energy. Range No. 2 bays were built to support higher energy gun systems. Gun systems up to 30-mm high velocity and 40-mm grenade launchers have been tested. Other than weapons and ammunition utilized in weapon development, a weapon/projectile stock is not maintained.

Environment

Each gun bay is enclosed to protect equipment from inclement weather and is maintained at a normal personnel environmental level.

Portable enclosures are used to enable climatic testing at controlled weapons and/or ammunition temperature (ambient to 180°F).

Live/Inert Fire

With proper safety precautions and depending on the range usage of adjacent bays, any type of projectile, include HE, may be fired.

Safety (and Security) Requirements

Unauthorized access to the test site is controlled by security guards at the main gate. In addition, an ordnance safety engineer is the test site administrator.

All buildings are completely equipped with automatic wet-type fire prevention systems, portable fire extinguishers and internal fire hoses.

Power Availability

3-phase, 115 VAC electrical power is available at all range bays and control rooms.

Observation/Communication

An air-conditioned observation control area is available at each bay. Intercom sets and internal and external public address systems are used to coordinate tests and warn personnel of an upcoming firing.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Photographic support is available at all locations, summarized briefly as follows:

1. Documentary - still and movie, color and black and white
2. High speed technical - black and white and color to 11,000 frames/sec
3. Cameras available include:
   a. Arriflex
   b. Fastex
   c. Milliken
   d. Hycam
   e. Photosonics.

A sound syncronization system is used to syncronize audio with the film and aid in reducing data from the film.

Of special interest in the portable micro-flash system available to all bays. The micro-flash system is a technique for stop motion photography of a projectile in flight. This technique has been used to determine projectile attitude, change of attitude, and physical condition. It was used extensively during plastic rotating band development testing.

TIMING. A sequential timer, 10 channels to 99.99 seconds in 0.01 second steps is available.

TELEMETRY. All gun bays have been extensively equipped to handle a variety of types of ordnance instrumentation. Each bay has the folloiwng basic hardwire intercabling to the instrumentation room:

1. 10, coaxial cables
2. 10, 8 conductor strain-gage shielded cables
3. 10, 3 conductor shielded cables
4. 20, 2 conductor shielded cables

Instrumentation is available to measure a broad variety of weapon system parameters characteristics. Typical instrumentation available is listed below.

1. Pressures, up to 100,000 lb/in^2 gage and 3000 lb/in^2 differential
2. Hydraulic fluid flow, up to 60 gal/min
3. Sound pressure, to 200 dB, at frequencies to 100 KHz
4. Component temperature -200 to +2000°F

5. Blast pressure, to 100 lb/in^2
6. Linear displacement, to 6 inches
7. Linear acceleration
8. Magnetic pick-up
9. Strain gage
10. Projectile velocity.

OTHER. The projectile velocity measuring system consists of photo-cell ballistic velocity screens, computing chronograph and high-speed printer. The capabilities include recording the number of rounds fired (burst size), velocity of each projectile (to 200 rounds/sec), computation of the average velocity of all rounds in a burst, and computation of the average rate-of-fire of any group of rounds in a burst.

Terminal Ballistic Instrumentation

The instrumentation at this facility is oriented to gun functions and in-flight ballistics.

Environmental Simulation and Measurement

Temperature environments of 180°F can be provided using portable shelters. Some rain, wind, and dust environments can be provided.

OUTDOOR FACILITIES

UPPER GUN RANGES

Located between the area occupied by Gun Ranges 1 and 2 and the thermostructural test area are three outdoor ranges; the Turret Range, the 1000 Meter Range and the Special Test site.

Dimensions

The Turret Range is placed on a ridge looking across a canyon. Its location provides for firings in azimuth from minus 90 degrees to plus 90 degrees and down to minus 80 degrees in elevation. It is ideal for operating in simulated helicopter firing modes. A 4000 pound jib crane provides ease of installation for the various test fixtures.

Located adjacent to the Turret Range is the 1000 Meter Range. The range provides for fixed line-of-sight firings of up to 1000 meters. The range terminates in a natural embankment. Targets may be placed with reasonable ease at any range up to 200 meters and at 1000 meters. Between 200 and 1000 meters the ground falls away from the line-of-sight. The firing line slopes downward 7 degrees to the impact area. At the pad area are a gun mounting pad and protective personnel wall.

The Special Test Site consists of an outdoor test area with earthen bunkers, an instrumentation building and test area hoist. This area has been used to test the S/V (survivability/vulnerability) of aircraft gun feed systems. In these tests rounds were fired into simulated feed systems containing live HE rounds to determine S/V capabilities. The firing distance depends upon the accuracy of the weapon and maximum allowable safety factors.

Weapons/Projectiles Available

The Turret Range can accommodate all weapons up to 40-mm. The 1000 Meter Range can accommodate weapons up to 40-mm. The Special Material Test Site can accommodate weapons up to 40-mm firing into weapons systems up to 25-mm.

Environment

The ranges discussed, being outdoor, are subjected to the ambient environmental conditions.

Live/Inert Fire

Both live HE and inert have been utilized on all outdoor ranges.

Safety (and Security) Requirements

Unauthorized access to all test sites is controlled by security guards at the main gate.

Fire protection is provided by mobile fire equipment (mounted on a truck).

Power Availability

Electrical power of 110- and 220-VAC is available.

Observation/Communication

Limited visual observation is available at the Turret Range and 1000 Meter Range. The Special Material Test Site has closed-circuit monitor and recording television facilities.

Instrumentation

All instrumentation, data acquisition, and control equipment are brought up from the Gun Ranges and installed in on-site trailers as required.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

A broad variety of recording systems are available; strip chart, oscillograph, and magnetic tape.

The data acquisition rooms at the Gun Ranges contain the following data acquisition equipment:

1. 36-channel oscillograph with galvonometer frequency response to 5000 Hz. CEC 5-119 or Honeywell 1208.

2. 18-channel strain gage power supply and balance - Owens or Allegany.

3. 18-channel(s) thermocouple temperature measurement with ice reference and pace thermocouple calibrator

4. 12-channel(s) charge amplifier - Kistler

5. 4-channel(s) of projectile velocity measurement equipment - ECI

6. One 14-channel tape recorder with frequency response DC to 10 KHz

7. 27-channel(s) amplification using Allegany, Dana or Astrodata amplifiers.

Additional instrumentation and digital computing capabilities are available from a mobile, general purpose instrumentation van, and the large-scale digital computing facility at Newport Beach.

QUICK-LOOK CAPABILITIES

Photographs, digital counters, strip charts, and oscilloscopes provide quick-look data.

PROCESSING

System and Model

The facility has a time share terminal (teletype) to the Newport Beach facility's Honeywell 604 system.

The mobile, general purpose van containing a Data General Nova computer with 32K memory.

Language

The time share terminal uses FORTRAN. The NOVA system, located in the general purpose van, has been programmed in assembly language in the past, but the recent purchase of a Real Time Disc Operating System will permit programming in FORTRAN.

Input/Output Options

The time-share terminal has a teletype output. In the past, graphics systems have also been used.

The general purpose van contains a magentic tape recorder, line printer, and oscilloscopes.

Realtime/Interaction

None for ballistic testing.

DISTRIBUTION

Turnaround time for photograph is usually 24 hours. Data reduced in the Data Acquisition Room at the Gun Ranges is usually available the same day as the test (if test load is light). Larger numbers of tests will increase turnaround time.

Turnaround time for the time Share Terminal is usually 24 hours.

DISPLAYS

The Gun Range Data Acquisition Room provides digital counters, strip charts, and oscillographs for data display.

Teletype, and graphics systems provide data display at the time-share terminal.

The mobile van has oscillographs, line printers, and video displays.

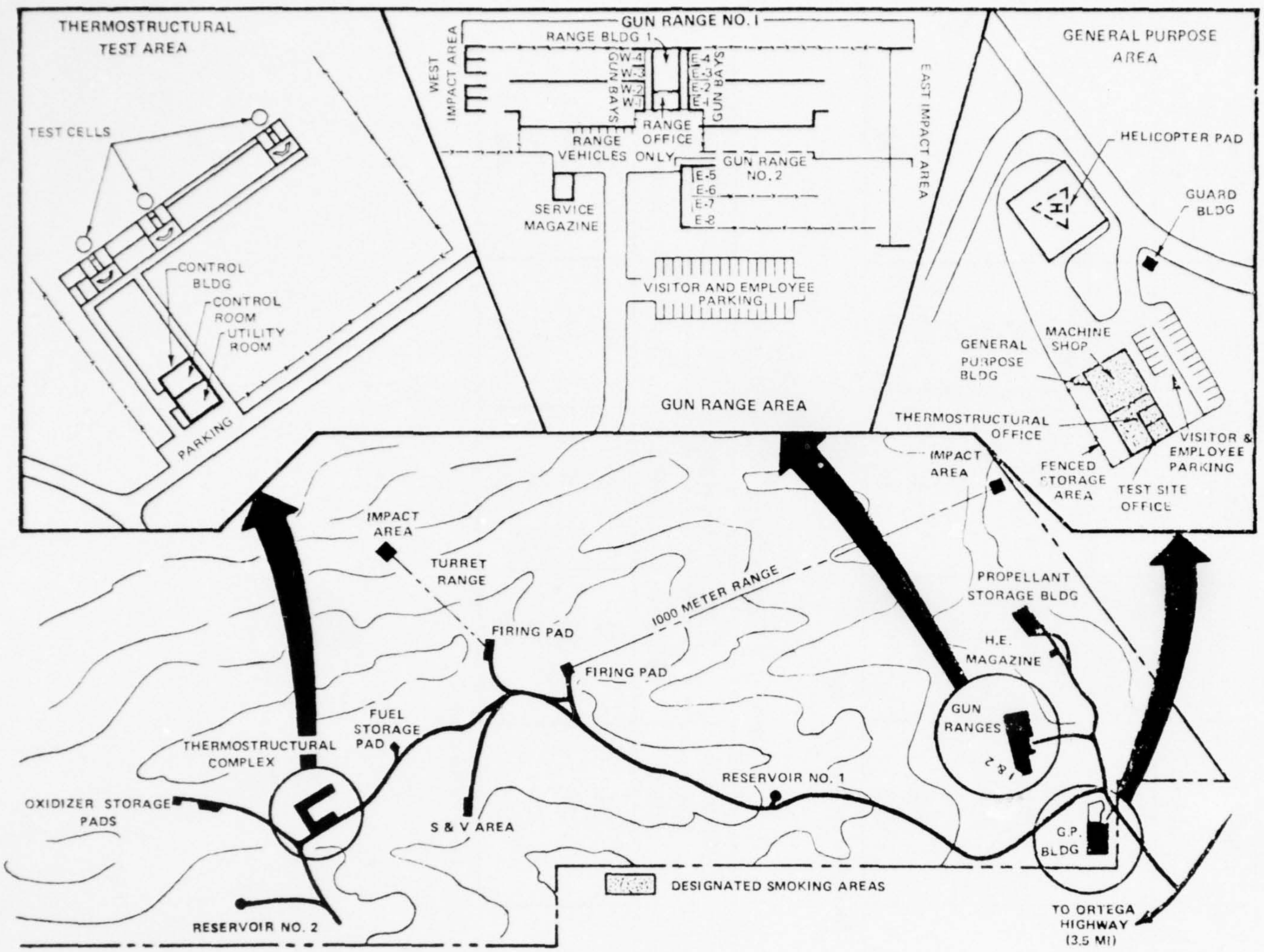


Figure M-1. Philco-Ford Capistrano Facility.

Table M-1. Gun Range No. 1 Dimensions.

Bay	Maximum range, meters	Dimensions, ft			Allowable pad static force, K lb[a]
		Height	Width	Depth	
W1	70	8	16	20	50
W2	70	8	16	20	50
W3	70	8	16	20	125
W4	70	8	16	20	125
E1	250	8	16	10	50
E2	250	8	16	10	50
E3	250	8	16	10	50
E4	250	8	16	10	100

[a]Horizontal and 3 feet above pad.

Table M-2. Gun Range No. 2 Dimensions.

Bay	Maximum range meters	Dimensions, ft			Allowable pad static force, K lb[a]
		Height	Width	Depth	
E5	250	12	20	24	200
E6	250	12	20	24	200
E7	250	12	20	24	200
E8	250	12	20	24	200

[a]Horizontal and 3 feet above pad.

ANNEX N - INTRODUCTION

OVERVIEW

The H. P. White Laboratory is located on 95 acres of land in an agricultural community north of Bel Air, MD. The laboratory includes approximately 30,000 ft^2 of floor space devoted to offices, ordnance library, ordnance museum, photographic darkroom, machine shop, two indoor firing ranges of 35 feet and 100 yards, explosive loading building, remote aircraft gun system test facility, store rooms and explosive magazines. The outdoor facilities include explosive test sites and a 400-meter range.

The H. P. White Laboratory was founded in 1936, by Mr. Henry Packard White as a ballistic research and development facility. Since that time, it has become one of the leading privately owned laboratories engaged in small arms and munitions research, development and testing.

This laboratory is believed to be the only independent ballistic test facility since it produces no manufactured end items and is in no way affiliated with any other research organization, manufacturer or end product user. During the 39 years of its existence H. P. White Laboratory has performed internal, external and ballistic tests and evaluations on a broad range of ordnance material, including small arms, machine guns, aircraft gun systems, and mortars. In addition, they have had extensive experience in testing armor plate, personnel protection equipment, HE (high explosive) projectile fuzing, pyrotechnic time delays and flares, incendiary devices, mines and fragmenting devices of a wide variety.

The H. P. White Laboratory has been founded on integrity of service, coupled with expedient, low-cost test and evaluation efforts. Its motto is "one test is worth a thousand expert opinions." The primary point of contact for the use of the H. P. White Laboratory facilities is Mr. Donald R. Dunn, telephone 301-838-6550.

One of the most important assets of the facility is its technical library. The library contains virtually every publication, text, periodical and training manual published since 1800 on the subject of fire arms, munitions, ballistic warfare and various fields of engineering.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The H. P. White Laboratory does not normally test aircraft systems or subsystems such as wings, fuselage, propulsion system or fuel cells. The laboratory, however, does do significant testing of armor plate and various penetration tests of a variety of targets which can be used to simulate aircraft systems.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There are four ballistic test facilities applicable to the aircraft S/V evaluation mission at H. P. White. Two of these facilities are indoors, one being a 35-foot-range and the second being a 100 yard enclosed range. The two outdoor facilities include a 400 meter bunkered range with additional bunkers at 100, 200, and 300 meters as well as an all-angle firing pit used currently for the AH1G COBRA Gun test.

ACCESS

The only access to the H. P. White Laboratory is by road. From Interstate 95 at the Bel Air, MD exit, proceed north on Maryland Route 24 through Bel Air to U.S. Route 1. Proceed north on Route 1 to Sandy Hook Road. Turning left, proceed approximately 1 mile turning right onto Scarboro Road, H. P. White being approximately 100 yards down the road. H. P. White is approximately 20 miles from Aberdeen Proving Ground so the Phillips Airfield could also be used to airlift articles into Aberdeen and then trucked from Aberdeen to H. P. White Laboratory. Suitable cleared area exists at the H. P. White Laboratory to permit use of a helicopter as a more expeditious means for movement of material and personnel.

MAINTENANCE/FABRICATION CAPABILITY

The machine shop at H. P. White Laboratory occupies approximately 200 ft^2 on the ground floor of the building and is primarily used to support the testing and evaluation efforts of the laboratory. Frequently, however, this facility is used to fabricate prototypes, replacement parts and to alter components under test. A limited amount of precision dies and limited quantities of precision parts are fabricated here, using comparators and microscopes for quality control and dimensional analysis.

Ammunition handling and loading facilities of H. P. White Laboratory are used to fabricate, develop and assemble a wide variety of ammunition components, including fuzed HE projectiles, saboted flechettes and small arms ammunition. Ammunition handling and weapons storage include facilities approved for classified items.

LOGISTICAL SUPPORT CAPABILITY

The H. P. White Laboratory has a limited logistical support capability. It can store ammunition and classified material within the laboratory; the user must, in most instances, supply all logistical support for items under test. Armor plate targets and instrumentation logistical support can be handled by the laboratory. Once more the close proximity of H. P. White Laboratory to Aberdeen Proving Ground (some 20 miles) allows logistical support from Aberdeen to be rather easily performed.

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BALLISTIC TEST FACILITY GUIDE. (U)

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INDOOR FACILITIES

THE 35-FOOT BALLISTIC RANGE

Dimensions

The 35-foot range is square approximately 10 feet by 10 feet and 35 feet long. It can be instrumented from the internal ballistics of the gun to the bunker at the end of the 35 foot range. No viewing ports are located along the 35 foot length of the tunnel to allow visual indication of performance. When applicable such observations are provided by a variety of photographs and x-ray techniques.

Weapons/Projectiles Available

Projectile launchers (guns and test barrels) for all calibers are available up to and including 30-mm projectiles. No HE projectiles can be fired in this 35 foot range.

Environment

Temperature conditioning chambers are available at this range.

Live/Inert Fire

Only inert projectiles can be fired on the 35 foot range. This includes AP (armor piercing) ammunition.

Safety (and Security)Requirements

Standard safety operating procedures are normally utilized on the 35 foot ballistic range. The H. P. White facility does possess classified gun vaults in which all foreign weapons are normally secured. Special procedures would have to be implemented if a classified weapon were to be left installed on a range overnight.

Power Availability

Normally 12, 14, 28, 110, and 220 VAC 3-phase power is available to the 35 foot facility. Generating equipment can provide additional power flexibility.

Observation/Communication

Only observation in the gun firing room is available on the 35 foot range. Normally firings are observed post flight from high-speed photographs or x-rays.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. High-speed cameras are available with frame rates of 2000 to 6000 frames/sec and 14,000 frames/sec.

TIMING. Timing is accomplished by the use of Lumiline screens, maker and breaker circuits and elapsed time counters.

TELEMETRY. Normal gun functions are monitored during tests.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Both single channel and 2-channel flash x-ray systems can be used in the 35 foot range. The 2-channel system can provide two orthogonal views of 150 and 180 kVA. In addition, three 16-mm high-speed motion picture cameras are available, one possessing the capability of 14,000 frames/sec. The other two can perform at from 2000 to 6000 frames/sec. Microflash photographic equipment is also available using four pulsed strobe lights.

TIMING. The timing systems that are normally used in the 35 foot range are the motion picture camera frame rate and electronic counters used for monitoring gun functions and the paper and graphite velocity breaks used for the facility.

Environmental Simulation and Measurement

Hot and cold conditioning chambers capable of temperatures ranging from -65°F to +200°F are available. Temperature measurements are performed by monitoring the output of fuel thermocouple probes with a chart recorder. No other capability to simulate or measure environmental conditions currently exists in the 35 foot range.

THE 100 YARD INDOOR BALLISTICS RANGE

Dimensions

The 100 yard indoor range is approximately a 10 ft^2 with conduit mounted the length of the firing range for set up of velocity breaks and various target configurations.

Weapons/Projectiles Available

The 100 yard ballistic range can handle anywhere from 5.56- to 30-mm inert projectiles. In addition, it can handle smaller fragments of various shapes.

Environment

Temperature conditioning chambers are available at this facility.

Live/Inert Fire

No HE projectiles can be accommodated by this facility.

Safety (and Security) Requirements

The standard operating procedures are normally utilized for the 100 foot test range.

The H. P. White facility does possess classified gun vaults in which all foreign weapons are normally secured. Special procedures would have to be implemented if a classified weapon were to be left installed in the range overnight.

Power Availability

Normally 12, 14, 28, 110, and 220 VAC 3-phase power is available to the 100 foot facility. Generating equipment can provide additional power flexibility.

Observation/Communication

Observation only in the gun firing room is available at the 100 foot range. Normally, firing is observed post flight through high-speed photographs or x-rays.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Three high-speed motion cameras are available, one operating at 14,000 frames/sec, and two operating at from 2000 to 6000 frames/sec.

TIMING. Electronic counters of microsecond accuracy are available for use.

TELEMETRY. Gun functions can be measured and recorded.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Both single channel and 2-channel flash x-ray systems can be used in the 100 foot range. The 2-channel system can provide two orthogonal views of 150 and 180 kVA. In addition, three 16-mm high-speed motion picture cameras are available, one possessing the capability of 14,000 frames/sec; the other two can perform at from 2000 to 6000 frames/sec. Microflash photographic equipment is also available using four pulsed strobe lights.

TIMING. The timing systems that are normally used in the 100 foot range are the motion picture camera frame rate and the electronic counters used for monitoring gun functions and the paper and graphite velocity breaks used for the facility.

TELEMETRY. Standard strain gage technology can be used.

OTHER. A 30-mm nondestructive projectile recovery fixture is available for use. The fixture is capable of recovering 5000 grain projectiles fired at muzzle velocities of 5000 ft/sec.

Environmental Simulation and Measurement

Hot and cold conditioning chambers capable of temperatures ranging from -65°F to +200°F are available. Temperature measurements are performed by monitoring the output of fuel thermocouple probes with a chart recorder. No other capability to simulate or measure environmental conditions currently exists in the 100 yard range.

OUTDOOR FACILITIES

THE 400 METER BALLISTIC RANGE

Dimensions

The 400 meter ballistic range is located on the side of the laboratory building and the firing is done into a sand butt against the mountainside behind the laboratory. Bunkers are available at ranges of 100, 200, 300, and 400 meters.

Weapons/Projectiles Available

The outdoor 400 meter ballistic range can accommodate projectiles up to and including the 57-mm antiaircraft gun projectile. All types of projectiles and projectile systems including AP, armor piercing incendiary, high explosive incendiary and high explosive incendiary tracer can be accommodated by this facility.

Environment

Only ambient atmospheric conditions are available at this outdoor facility.

Live/Inert Fire

Live fire can be accommodated by this facility up to and including large fragmenting munitions with certain safety constraints being required to meet safety requirements.

Safety (and Security) Requirements

Standard safety procedures are available for the 400 meter range at H. P. White; however, if large fragmenting munitions are used special safety precautions must be taken on or beyond the hill at the end of the 400 meter range.

Power Availability

Normally 12, 14, 28, 110, and 220 VAC 3-phase power is available at this range. Power generating equipment can be used to supplement available power at the firing site if required.

Observation/Communication

Tests may be observed from inside the laboratory for the 400 meter ballistic range and from a variety of bomb proof enclosures.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The three high speed 16-mm motion picture cameras provide a majority of the photographic coverage for this facility. One of the high-speed cameras operates at 14,000 frames/sec and the other two from 2000 to 6000 frames/sec.

TIMING. Camera frame rates, velocity measuring instrumentation (electronic counters) and gun function hardwire instrumentation are the only timing systems used on this range.

TELEMETRY. All gun functions can be measured and recorded. Velocity measurements can be made with either maker or breaker circuits or Lumiline screens.

OTHER. A 20-mm nondestructive recovery fixture is available for use.

ALL-ANGLE FIRING PIT

Dimensions

The All-Angle Firing Pit is approximately 100 feet in diameter. It consists of fragment barricades around the circumference and a firing pedestal in the center with power outlets and remote firing position specially designed for aircraft armament testing.

Weapons/Projectiles Available

The range is specially designed to accommodate aircraft armament systems. The all-angle test site was designed for the testing of automatic slew and elevation, high rate of fire gun systems with a total elevation variation of 70 degrees and traverse from minus 120 degrees to plus 120 degrees. Weapon systems up to 40-mm can be accommodated.

Environment

This outdoor facility has only open air ambient conditions. The firing position is covered overhead and as specifically designed for all-weather operation.

Live/Inert Fire

Live fire of aircraft gun systems can be accommodated at this range up to 40-mm.

Safety (and Security) Requirements

All firing on this range is remotely controlled from bunkers located within the facility.

Power Availability

Power outlets specially designed to meet aircraft weapons systems requirements are available.

Observation/Communication

Direct observation of tests is possible from the bunkered portion of the facility.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. High speed photography is available for the observation of in-flight ballistics, terminal ballistics, and firing position. Frame rates are available from 2000 to 6000 frames/sec and 14,000 frames/sec.

TIMING. Timing is accomplished by elasped time counters, oscillograph, x-ray and high-speed photography.

TELEMETRY. All gun functions are observed directly and instrumentally monitored.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Terminal ballistic photography is provided by high-speed cameras, x-ray and microflash photography.

TIMING. There is no terminal ballistic timing.

TELEMETRY. There is no terminal ballistic telemetry.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Measurements taken on the ranges are recorded with a multi-channel tape recorder with oscilloscope display. The system is fitted with a polaroid adapter to provide a permanent visual record.

QUICK-LOOK CAPABILITIES

There are no quick-look capabilities

PROCESSING

No computer capabilities exist.

DISTRIBUTION

High speed films can be processed in under 30 minutes. X-ray film can be viewed in about 20 minutes.

DISPLAYS

High speed films can be projected at various speeds. A Vanguard Motion Analyzer is available for analysis of high speed motion photography. A magnifying viewer-plotter can be used for measuring irregularly shaped objects.

ANNEX O - INTRODUCTION

OVERVIEW

The VSD (Vought Systems Division) of LTV Aerospace Corporation, located in Dallas, TX, is the corporation component responsible for designing and manufacturing aircraft and missiles. The current employment of VSD is approximately 10,000 personnel.

The Structures and Systems Laboratories is the operating department responsible for S/V (survivability/vulnerability) testing. VSD is currently producing and testing the U.S. Air Force A-7D and the U.S. Navy A-7E attack aircraft. Also, under production is the 2-man YA-7H attack aircraft and the U.S. Army LANCE Battlefield Support missile. The primary contact for this facility is Mr. D. M. Reedy, telephone 214-266-2245.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

VSD is currently testing intermediate fixed-wing aircraft such as the A-7 and S-3A. Subsystems undergoing testing include fuel systems, armament, hydraulic subsystems, and propulsion systems.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The VSD Gunfire Test Facility is used for both ballistic S/V testing and ordnance research and development. The facility consists of a 6-inch thick concrete pad located 80 feet from a target butt capable of retaining 20-mm ammunition at rapid rates of fire (up to 6000 spm) and single-shot 30-mm rounds, with velocities controlled and measured. The pad is covered by a shelter roof. A shop building and control building are located nearby. A utility trench, used to accommodate instrumentation is located in the control room. Figure O-1 shows a plan view of the facility. The range, at present, cannot accommodate HE (high explosive) rounds, HEI (high explosive incendiary) rounds, or fragmentation rounds.

ACCESS

Primary access to the facility is via Jefferson Street parallel to the Dallas-Fort Worth Turnpike. A company owned spur is available to the Texas and Pacific Railroad. Air access is via the Dallas Naval Air Station, east of the facility.

MAINTENANCE/FABRICATION CAPABILITY

Facility maintenance is provided by the VSD Plant Maintenance Department. The Structures and Systems Laboratories have a laboratory machine shop and a sheet metal fabrication shop with capabilities of fabricating precision test fixtures and hardware. Backing up the Structures and Systems Laboratories are the capabilities of the VSD Manufacturing Department.

LOGISTICAL SUPPORT CAPABILITY

The plant provides required logistic support to the laboratories. The Safety Department is responsible for storage of all ammunition. All classes of ordnance can be accommodated and certified technicians are available to handle explosives as required. Portable fuel supply tanks, pumps, and pressurization systems are available to the facility for survivability testing of fuel tanks.

INDOOR FACILITIES

None.

OUTDOOR FACILITIES

GUNFIRE TEST FACILITY

Dimensions

The Gunfire Test Facility, shown in Figure O-1, is the only armament facility at VSD. The facility consists of a 6-inch thick concrete pad 60 feet long by 40 feet wide, located 80 feet from a target butt capable of retaining 20-mm rapid fire and 30-mm single-shot projectiles. Figure O-2 shows a cross section of the gun butt. The pad is partially covered by a shelter roof, 24 feet wide by 30 feet long and is 15 feet high. Maximum firing range available at the facility is 150 feet. Present range is 93 feet.

Adjacent to the pad is a 20 by 20 foot shop building. Control room space is provided in a neighboring High Temperature Test Facility Building.

Weapons/Projectiles Available

The Gunfire Test Facility is capable of handling projectiles to 30-mm, with velocities precisely controlled and measured. Table O-1 shows the maximum projectile velocity and kinetic energy and impact for the various weapons available at the facility.

In addition to straight-in shots, tumbled-round shots can be performed.

Environment

The test specimen can be dynamically or statically loaded with load jacks to simulate in-flight conditions. Although the enclosure is not designed to simulate environmental conditions, special environments can be artifically created with portable heaters, vibrators, or fans.

Live/Inert Fire

The facility cannot be used to fire HE or HEI rounds. Also, no fragmentation rounds are fired on the range.

Safety (and Security) Requirements

The Gunfire Test Facility is located within a secure, guard-protected area. In addition, lights and horns warn all personnel in the area that gunfire testing is in progress.

Power Availability

Six circuits of 20-ampere, 110 vac, and one circuit of 30-ampere, 3-phase 480 VAC of electrical power are available in the shop building. Two 20-ampere, 10 VAC circuits are available at the utilities trench. Electrical power for instrumentation is available in the control room area.

Plant air is available in the shop building. An 8-inch air line with a quick operating valve provides 4 lb/sec of plant air at 80 lb/in^2 pressure to the far end of the utilities trench.

Observation/Communication

Portable shields are available for area observation. Walkie-talkie and intercom networks can also be set up between the gunmount, test specimen and control room.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A printed circuit type; digital cascade counting chronograph is used to meausre projectile velocities to 10,000 ft/sec.

TIMING. Hewlett-Packard preset counters are used for test sequencing and time correlation.

TELEMETRY. None available for in-flight ballistics.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. High-speed (to 9000 frames/sec) movie cameras of various types are used to record the overall response of a test specimen during the impact sequence.

TIMING. Hewlett-Packard preset counters provide the proper time sequencing of events during testing. Time code generators are available to provide data time correlation for the ground ballistic S/V tests.

TELEMETRY. Telemetry equipment is available at the Flight Test Facility, but has not been utilized in ballistic S/V testing. A portable instrumenation cart is located in the adjacent shop building. Transducers are available to measure:

1. Accelerations to ±10,000 g's
2. Loads to 100,000 pounds

3. Pressures to 10,000 lb/in^2
4. Temperatures from -100°F to +1000°F
5. Flow rates to 600 gal/min
6. Deflections as needed using load beams and linear pots.

OTHER. Instrumentation signal conditioners and general laboratory equipment are available to support ballistic tests.

Environmental Simulation and Measurement

Specimen loads to 100,000 pounds and temperatures from -100°F to +350°F can be provided.

PLANNED EXPANSION/MODIFICATION

Modifications required to accommodate HE rounds are being studied.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The test data is stored on magnetic tape or photographic film. These tapes and film are then filed by test request numbers. Some data are also available in hardcopy form (oscillograph records, photographs).

QUICK-LOOK CAPABILITIES

Hewlett-Packard counters, Honeywell and CDEC direct writing light-beam oscillographs with paper speeds to 160 in/sec and frequency response to 4800 Hz and oscilloscopes are used to provide quick-look. This equipment permits reproduction or display of expanded time scales to facilitate identifying sequences and time correlating of events.

PROCESSING

System and Model

Automatic data processing is not available at the facility but the Flight Test Center can handle processing jobs as required. The center has a SIGMA 7 computer with a full complement of peripheral equipment, and can give outputs printed or as curved plots.

Language

The SIGMA 7 uses the FORTRAN programming language.

Input/Output Options

Input/output equipment includes:

1. Card Reader
2. Card Punch
3. Line Printer
4. Magnetic Tape
5. Teletype.

Realtime/Interactions

None at this facility.

DISTRIBUTION

Turnaround times are 24 hours for photograhic data and from 24 hours to 1 week for formatted hardcopy data.

DISPLAYS

Hardcopy from the line printer and visicorders and a CRT provide data displays. Magnetic tapes from the SIGMA 7 are used to generate plots on an off-line EAI plotting system.

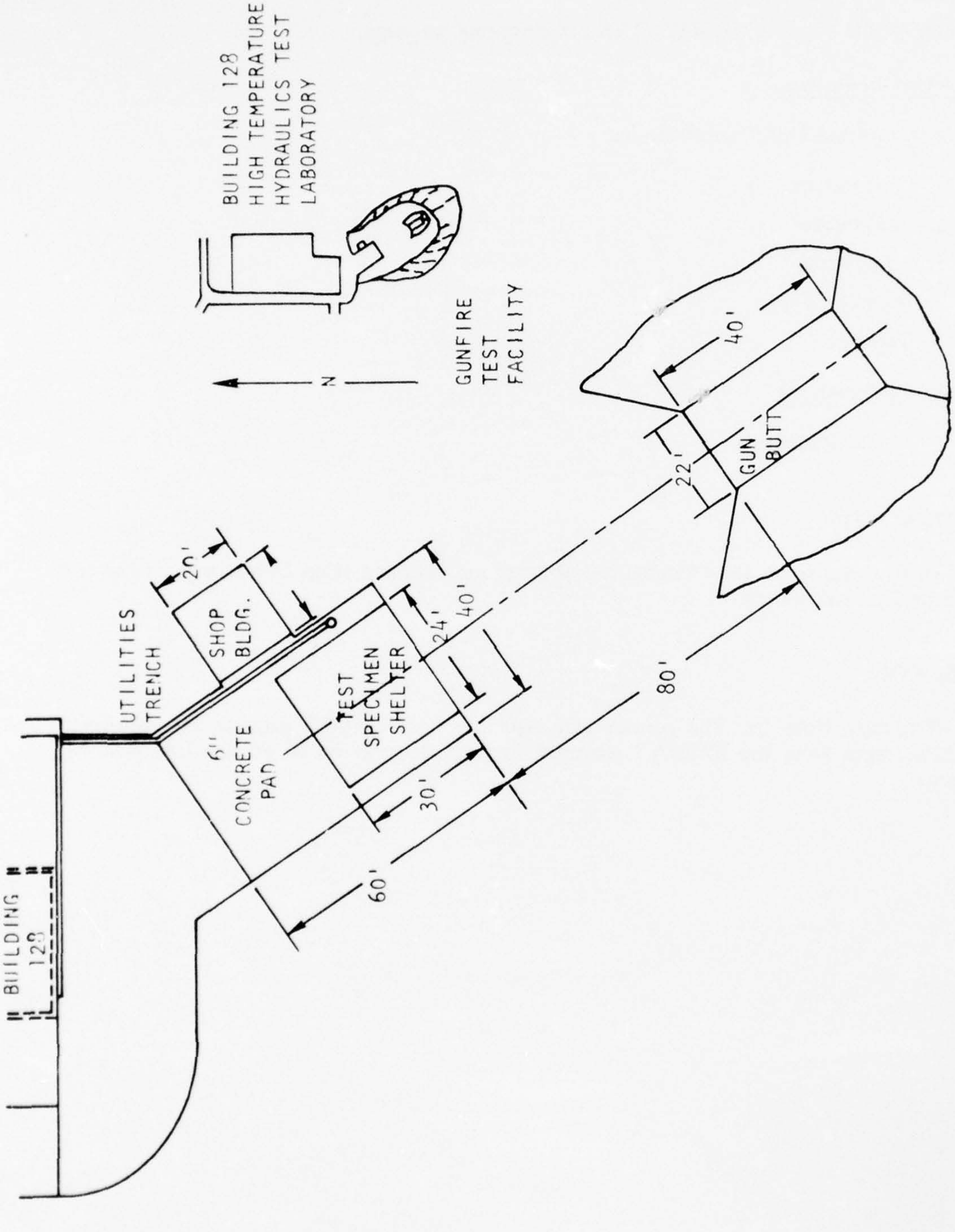
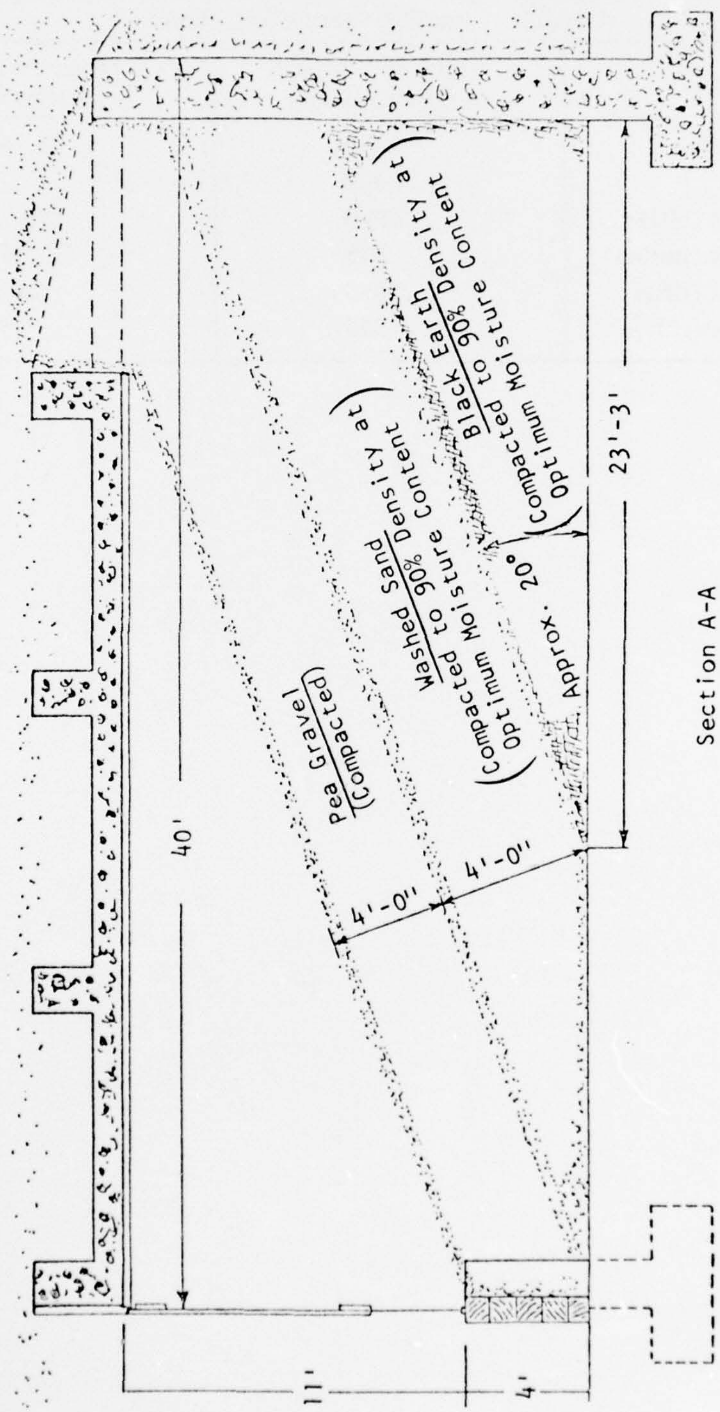


Figure O-1. Plan View of Vought Systems Division Ballistics Facility.



Section A-A
Scale: 3/8" = 1'-0"

Figure O-2. Gunfire Test Facility.

Table 0-1. Projectile Impact Velocity and Impact Kinetic Energy Available at the VSC Gunfire Test Range.

Weapon	Projectile impact velocity, ft/sec	Projectile impact energy, ft/lb
20 mm (MG)	2730	26,745
14.5 mm	3400	. . .
.50 caliber (MG)	2900	13,072
.45 caliber (pistol)	850	369
.30 caliber (rifle)	2680	2654
.22 caliber (rifle)	1335	158

ANNEX P - INTRODUCTION

OVERVIEW

McDonnell Aircraft Company, a component of McDonnell Douglas Corporation, is located adjacent to the Lambert - St. Louis Airport, St. Louis County, MO. The Aircraft Company is responsible for the design and manufacture of fighter aircraft. The F-4 Phantom series and F-15 Eagle are presently being manufactured at the St. Louis facility.

Laboratory support available at the St. Louis Plant includes:

1. Armament and Explosives Laboratory
2. Propulsion Systems Laboratory
3. Fuel System Laboratory
4. Lightning Simulation Laboratory
5. Dynamics Laboratory
6. Physics Laboratory
7. Electronic Laboratory
8. Avionics Laboratory.

The A&E (Armament and Explosives) Laboratory, part of the Engineering Laboratories, is responsible for research, development, engineering evaluation, vehicle integration, qualification, and manufacturing support testing of armament systems and associated ordnance. The primary contact is Mr. Alan Wilkes, telephone 314-232-3985.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The A&E Laboratory tests all types of flight structures and systems for S/V (survivability/vulnerability) determinations when subjected to external armament threats or malfunction of integral and on-board armament. At present, subsystems of intermediate fixed-wing fighter aircraft (fuel cells, fuel lines, structures) are tested in the facility.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

McDonnell Aircraft Company has two ballistic facility locations. The Building 13C Gunfire Test Facility is employed for testing gunfire survivability designs as well as for testing gun systems themselves. Figure P-1 shows a plan view of the Gunfire Test Facility. The range is located on a 4-acre site and is comprised of a two-bay test cell, a single-bay test cell, a single-shot gun-fire tunnel, and a high-firing-rate gun-fire tunnel. Other facilities include:

1. Two enclosed test and test support bays
2. A seat/catapult ejection range

3. A ready-use explosives/ammo magazine
4. Two instrumentation and control trailers
5. Site shops and offices.

The gunfire facility located in Building 62 (Propulsion Systems Laboratory) is used to simulate in-flight airflow over aircraft during fuel tank ballistics tests. The test cell is presently set up for a gunfire/fuel tank fire and explosion suppression program (Figure P-2).

ACCESS

The St. Louis Facility can be reached via Lindbergh Boulevard and Brown Road off Interstate 270. A spur of the Norfolk and Western Railroad is available on the facility. Air transportation is via the Lambert - St. Louis Airport adjacent to the facility. The Mississippi River offers water transportation from the St. Lawrence Seaway/Illinois River to the north and New Orleans to the south.

MAINTENANCE/FABRICATION CAPABILITY

Laboratory shop equipment includes a metal lathe, bandsaw, grinder, drill press, and a sheet metal shear and brake. One shop area is equipped with explosion-proof electrical outlets and lighting, and is continuously supplied with air for purging solvent vapor to provide for cleaning, preserving, and assembly of missile launchers, pylons and racks, and gun systems.

In additon, the extensive capabilities of the airframe plant are available as required.

LOGISTICAL SUPPORT CAPABILITY

The facility is equipped for loading and preparation of ammunition, solid propellants and other explosive materials and devices, and disposal of materials. Two shop buildings comprise approximately 800 ft^2 of working space. A temperature and humidity controlled magazine provides ready-use storage of ammunition and explosives. Two trailers provide approximately 1000 ft^2 of office space.

INDOOR FACILITIES

GUNFIRE TEST FACILITY (Building 13C)

Dimensions

This faiclity has two functional sections. The 1000 inch range high-firing-rate tunnel provides for installed gun system testing and is constructed of 25 by 85 by 13 feet high reinforced concrete. A 7-foot deep by 8-foot square recessed and steel-plate covered

concrete block floor is used for reacting loads of a test fixture that rotates armor plate test specimens up to near sonic speeds. A movable gun/airframe section shelter, 24 by 30 by 16 feet high with opposite-end full-opening doors, telescopes over the tunnel to leave an unobstructed area for positioning and tieing down gun equipped aircraft.

The single-shot gunfire facility consists of a gunmount room connected to a 16 by 20 by 13 feet high test article bay by a 2 feet diameter, 60 feet long, steel tube. Another gunmount, equipped with a steel tube, provides a close range (approximately 10 feet) firing station. A full-side opening sliding door and a personnel door provide access to the bay.

Two 1800 square feet by 16 feet enclosed bays provide for assembly and modification of test articles and associated equipment and for conduct of various testing.

Out-of-doors test areas include an approximately 150 feet long by 40 feet wide ejection range.

Two tanks, 12 feet diameter by 10 feet deep and 10 feet diameter by 3 feet deep provide for underwater testing.

A chamber 3 feet in diameter by 5 feet long is used for testing explosion-proof capabilities of components in an explosive atmosphere (to 60,000 feet pressure altitude).

Weapons/Projectiles Available

Table P-1 lists the weapons and projectiles available at both the Building 13C facility and the Building 62 facility.

All weapons are mounted on a standard Frankford Arsenal Gun Mount. Production rapid-fire weapons can also be accommodated.

Environment

Specimen environments of high temperature, low temperature, flight loads, vibration, and target motion are available.

Live/Inert Fire

Both tunnels can accommodate AP (armor piercing), API (armor piercing incendiary), HE (high explosive), and HEI (high explosive incendiary) projectiles.

Safety (and Security) Requirements

The gunfire facility is completely within a secure area. In addition, CCTV (closed circuit television), gun gas sniffers, temperature measuring devices, and key operated firing switches are used to maintain safe operations.

The projectile impact end of the tunnels is backed by an earthen-reveted, reinforced-concrete structure that contains sand reservoirs backed up by armor plate which, in combination, absorb projectile energy, contains projectiles and shrapnel, and preclude excessive projectile penetration. A gun-firing-circuit grid-board terminates high-rate firing if projectile dispersion becomes excessive.

Power Availability

Numerous 440 VAC 3-phase electrical outlets in all standard sizes from 30 to 200 amperes inclusive are available.

Plant supplied shop air manifolds are also available. Two preflight air starter carts for jet engines and a 500 gallon compressed gas tank have been combined into a 500 psig blowdown air system.

Standard Flight-line "ground cart" aircraft system supply units are also used at the facility.

Observation/Communication

CCTV with recorders, intercoms and a public address system provide observation/communication between the test article and the fire control/instrumentation trailer.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Projectile velocities to 6000 ft/sec are measured by chronographs or high-speed cameras (to 20,000 frames/sec). Cameras available at the facility include:

1. Six Nova II Rotating Prism Cameras 1000 to 18,000 pictures/sec - 500 foot magazines

2. One Beckman & Whitney Model 200 Streak and Framing Camera (12 frames at 10^6 frames/sec)

3. A wide assortment of gun cameras, 64 to 1000 frames/sec.

Timing is provided from a central source, thus permitting exact correlation between cameras.

TIMING. Preset counters are used to sequence test events and determine projectile velocity.

TELEMETRY. The majority of the instrumentation at this facility is used to record gun functions and terminal ballistic parameters. All instrumentation is hardwired to the instrumentation and control trailer.

OTHER. Sniffer systems to measure the explosive levels of vented gun gases have been developed by the laboratory.

Modified visible light sensors are used to determine relative light and flash amplitude during tests.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The high-speed cameras are also used to monitor projectile-specimen impact. CCTV are also used to monitor and record tests.

TIMING. IRIG time code generators, a 50 MHz quartz crystal standard and preset counters are used to provide time correlation of ballistic data. The time code can be recorded on magnetic tape, film and oscillograph hardcopy.

TELEMETRY. Transducers available include:

1. Loads to 100,000 pounds
2. Pressures to 100,000 lb/in^2
3. Temperatures at -80°F to greater than 1000°F
4. Accelerations of 1 to 5000 *g*'s
5. Flow to 1200 gal/min.

All transducers are hardwired to a Vidar 84-channel FM multiplexed Data Station.

OTHER. Firing and camera control panels and instrumentation recorders for the 1000 inch range are in a trailer located about 50 feet north of the tunnel. Firing controls and instrumentation for the single-shot facility are in the gunmount room (Figure P-1).

Special instrumentation build-ups to satisfy specific requirements can be furnished by the lab if required for a specific test. Additional instrumentation is used, as needed, from central laboratory functions.

GUNFIRE FACILITY (Building 62)

Dimensions

A newly constructed remote gunfire facility, located in Building 62 (Propulsion System Laboratory) is being used for a gunfire/fuel tank fire and explosion program. The facility consists of a 8.5 feet high by 11.7 feet wide by 17 feet long test cell, with a 7 by 7 foot entry, ducted to a compressor (51,000 scfm at 100°F). A 12 by 12 foot control/observation room is also available. Maximum firing range is 75 feet. Normal firing range is 20 feet.

Weapons/Projectile Available

The facility can accommodate the .50 caliber and 14.5-mm projectiles.

Environment

In addition to the environments available at the Gunfire Test Facility, the remote facility can provide up to 400 knots air flow over the test specimen.

Live/Inert Fire

The remote facility can accommodate both inert and API projectiles.

Safety (and Security) Requirements

Cardox, H_2O deluge, safety sensors, CCTV monitoring, and warning lights and horns are used at the facility.

Power Availability

Power available at the facility includes 110, 220, and 440 VAC, and 28 VDC electrical power, compressor and shop air, and portable hydraulic carts.

Standard flight-line "ground cart" aircraft system supply units are also used at the facility.

Observation/Communication

CCTV (black and white) provides realtime observations. Intercoms are routinely used for communication. No direct observation of testing is available.

In-Flight Ballistic Instrumentation

The instrumentation at this facility is oriented to terminal ballistic testing.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The high-speed cameras are available to record projectile/specimen impact. CCTV is also used to monitor and record tests.

TIMING. IRIG time code generators and preset counters provide data time correlation. The time code can be recorded on magnetic tape, film, and oscillograph hardcopy.

TELEMETRY. Transducers available include:

1. Loads to 100,000 pounds
2. Pressures to 100,000 lb/in^2
3. Temperature of -80°F to greater than 1000°F
4. Flow to 1200 gal/min.

All transducers are hardwired to instrumentation in the facility control room.

Environmental Simulation and Measurement

This facility provides up to 400 knots of air flow over the test specimen. Other environments such as loads (to 75,000 pounds), temperatures (-65°F to +200°F), and accelerations (±5000 g's) can also be produced using Laboratory equipment.

OUTDOOR FACILITIES

None.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The majority of the data is stored either on magnetic tape, film, or oscillograph hardcopy.

An 84-channel Vidar FM Multiplex Data Acquisition System is located in the instrumentation and control trailer at the Building 13C facility. Ampex magnetic tape recorders, Honeywell and CEC oscillographs, and Vidar signal conditioners are available for data recording.

The engineering Laboratory's CDAS (Control Data Acquisition System) provides digital data acquisition, test monitoring, and on-line computation services to the laboratories. The CDAS is equipped to measure, record, and provide automatic calibration for voltage signals of various ranges. Data rates can be varied to satisfy requirements of the test.

QUICK-LOOK CAPABILITIES

Photographs, CCTV, and oscillographs provide quick-look data.

PROCESSING

System and Model

The CDAS mini-computer system has an 8000 16-bit word memory, disc memory capable of storing up to 200,000 16-bit words, two cassette tape recorders for program input/output, cathode ray terminal with graph capabilities and one typewriter interface input/output unit.

Language

This system uses either the manufacturers assembly language or FORTRAN.

Input/Output Options

Ancillery equipment for CDAS mini-computer includes:

1. Number of data channels - 600 (expandable to 1000)

2. Input Signal Conditioner - Six, each containing 100 channels

3. Test Site Control Units - Four, each capable of interfacing signal conditioning and peripherals to central control to configure a complete data system at any test site

4. Printers - Three, two for use at test sites, one at central control station.

Each test site control unit interfaces up to six Signal Conditioning Units, one Printer, one Scope, the High Speed Graphical Recorder, and up to three Low Speed Graphical Recorders.

Realtime/Interactions

Cathode ray tubes and teletype units can be used to interact in realtime with the CDAS if required.

DISTRIBUTION

Turnaround time depends upon amount of data required. Photographic film is developed in from 24 to 48 hours. Oscillograph records are manually reduced. Magnetic tapes are either reduced on-site or by CDAS on a priority basis.

DISPLAYS

Display options include:

1. Scope Displays - Two, for use at test sites

2. High Speed Graphical Recorder - One unit with six channels of digital-to-analog conversion, with four channels of strip chart, and two X-Y recorders

3. Low Speed Graphical Recorders - Three K-Loggers, each with 100 3- by 6-inch X-Y plots, 1 point/sec.

These displays are in addition to on-site digital readouts, oscillographs, and CCTV.

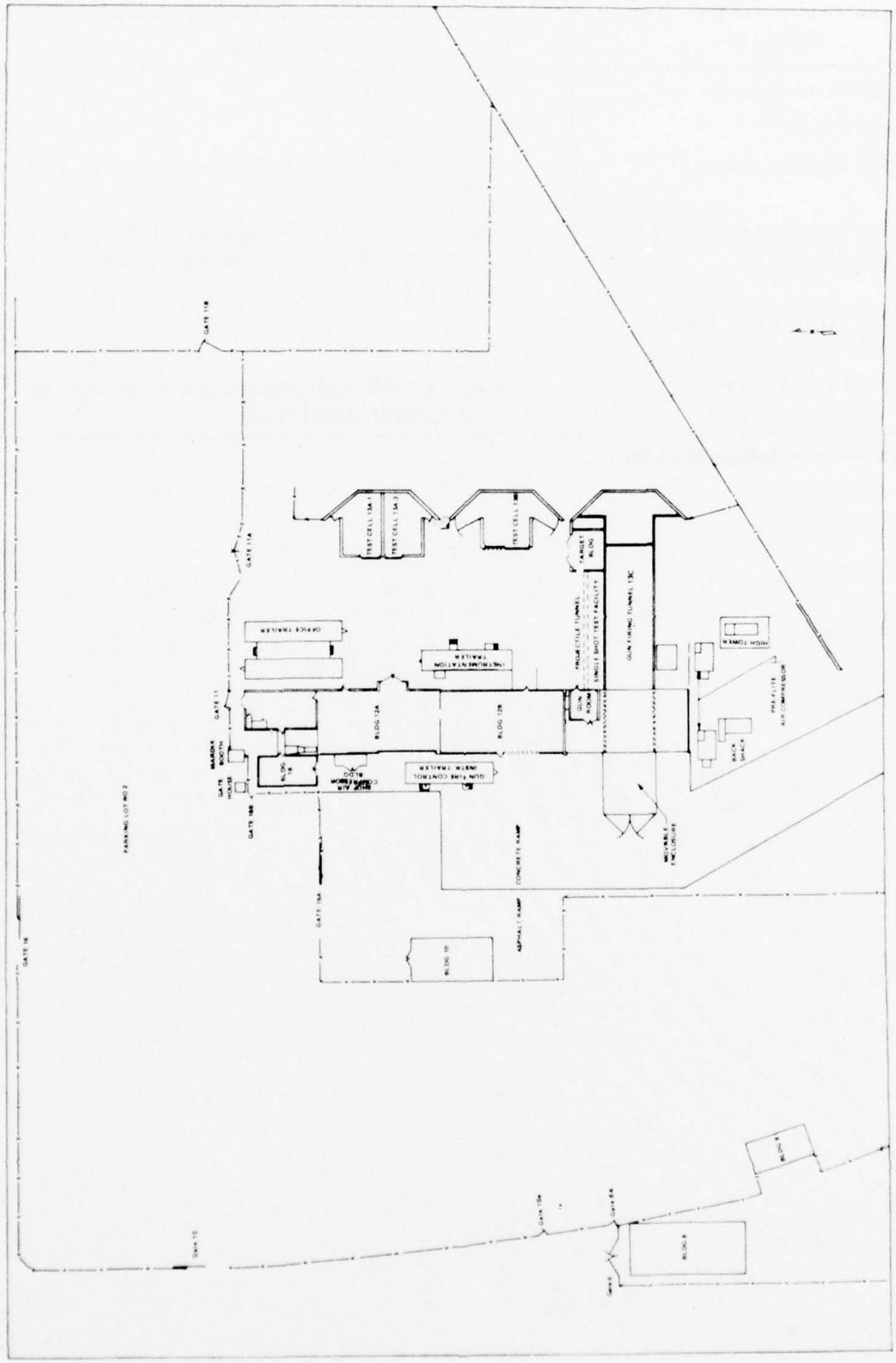


Figure P-1. McDonnell Aircraft Company Ballistic Facilities.

Table P-1. A & E Laboratory Weapons/Projectiles.

Weapons	Projectiles
20 mm (M61A1 barrel)	20 mm AP, Ball, HEI
14.5 mm (Russian)[a]	14.5 mm API
.50 caliber (ANM3 barrel)[a]	.50 caliber AP, API (Velocity controlled 1000 to 2800 ft/sec
.50 caliber (smooth bore fragment launch tube)[a]	Fragments 10 to 100 grams (velocities to 5600 ft/sec. Yaw controlled from 0 to 45 degrees)
.50 caliber (rifling one twist to 14-inch)[a]	
.30-06 (1917 Enfield)[a]	.30 caliber AP and commercial (velocity controlled 1800 to 3900 ft/sec)

[a]Can be used at Building 62 facility.

ANNEX Q - INTRODUCTION

OVERVIEW

The U.S. Steel Research Laboratory, located in Monroeville, PA, off the business route of U.S. Highway 22, has as its primary mission research in all areas of interest to U.S. Steel. Consistent with this overall objective, the Laboratory has an indoor ballistic range operated by the Heavy Products Division of the Laboratory. The indoor facility was constructed in 1967 to test potential tank and helicopter armor component materials.

The primary point of contact for the indoor facility is Dr. Lew F. Porter, Section Supervisor in the Heavy Product Division, telephone 412-372-1212, ext. 2893. Armor research is one of the areas under Dr. Porter's supervision.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The U.S. Steel Research Laboratory ballistic facility concentrates on the ballistic testing of steel armor plate. There is also a limited capability to test plate or small components at temperatures above or below room temperature. Steel for armor seats for helicopters has been tested in this facility.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There is only one indoor facility available at the U.S. Steel Research Laboratory. This facility has approximately a 30-foot usable range and can handle .30 and .50 caliber and 20-mm AP (armor piercing), ball and fragment-simulation ammunition. Also, 5.56-mm (.22 caliber) and shotgun projectiles have been fired in this facility.

ACCESS

Primary access to this indoor facility is by road using U.S. Highway 22 Business alternate through Monroeville, PA, to Monroeville Boulevard and Jamison Lane. Railroad facilities at Pitcairn, PA, can be used as terminal points for test items shipped by rail. All airfreight is handled via the Greater Pittsburgh International Airport.

MAINTENANCE/FABRICATION CAPABILITY

Maintenance and fabrication capabilities at the U.S. Steel Research Laboratory are extensive as would be expected for a major steel manufacturer research laboratory. Both one of a kind items and normal U.S. Steel production items can be handled easily at this facility.

LOGISTICAL SUPPORT CAPABILITY

Powder is normally bought commercially by the laboratory. Ammunition is purchased from the U.S. Army, and the .30 and .50 caliber, and 20-mm gun barrels are Government property controlled by existing research contracts with the AMMRC (Army Materials and Mechanics Research Center) in Watertown, MA.

INDOOR FACILITIES

HEAVY PRODUCTS DIVISION BALLISTIC RANGE

Dimensions

The ballistic range is 44 feet in total length with only 30 feet of usable firing range. The range is 10-feet-wide by 8-feet-high and is separated into two areas: launcher/in-flight ballistics area and the target/terminal ballistics area.

Weapons/Projectiles Available

Three U.S. Army supplied rifled barrels are available at this facility, .30 and .50 caliber, and 20-mm. The laboratory has its own .22 caliber rifled barrel. Fragment simulators can be fired in the four various sizes of barrels. Ball ammunition is available for .30 caliber only. AP ammunition is available for all barrels except .22 caliber.

Environment

The ballistic range is normally used to test armor at ambient pressure and temperature conditions. A furnace can be used to heat the target to 1200°F for testing of such articles as turbine blades at operational temperatures, and low-temperature baths can be used to cool targets to temperatures between room temperature and liquid-nitrogen temperature (-196°C).

Live/Inert Fire

AP, ball and fragment-simulation projectiles can be fired on this range into primarily steel target plates.

Safety (and Security) Requirements

All firing is conducted from the fire control room. An interlock system is used to prevent or interrupt firing when personnel are either in the terminal target area or the weapon firing room. Audio communications are available for the terminal area, the weapon firing area, the office area, as well as the fire control room.

There is no capability to store classified material weapons or documents at the facility itself. Classified documents are stored in a classified safe which is located in Dr. Porter's office.

Power Availability

Both 110 and 220 VAC power is available at the facility. If required, 28 VDC could be made available.

Observation/Communication

No realtime observation is available in this facility. Communication system exists which links the test firing center with the office area, the launcher room, and the terminal room.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Only terminal ballistic photography is used on this range.

TIMING. Two counting systems are used in conjunction with the velocity meters on this range. The first is the Hewlett Packard 5233L photo counter used in conjunction with the light break velocity measurement system. The second timer is the Counter Chronograph Model T333A used in conjunction with the paperbreak velocity meters. Both velocity measurement devices use a ten foot baseline and are mounted in the middle third of the ballistic range.

TELEMETRY. *No telemetry* or hardwired functions are currently available at this facility.

Terminal Ballistic Instrumentation

All high-speed photography capability at the U.S. Steel Research Laboratory is under the direction of the Measurement Research Section of the Electrical Systems Division. Capability exists to use up to 22,000 frames/sec cameras at the laboratory. To date only the 10,000 frames/sec cameras have been required at the ballistic range.

In addition to the realtime photograhic capability complete photographic facilities for post-flight still photography are available at the Research Laboratory.

Environmental Simulation and Measurement

The only environmental simulation is the ability to heat the target material up to a maximum temperature of 1200°F prior to firing or to cool a target to temperatures between room temperature and liquid-nitrogen temperature (-196°C).

Planned Expansion/Modification

No modification or expansion is planned for this facility at this time.

OUTDOOR FACILITIES

None.

DATA HANDLING/PROCESSING

All data handling processing is accomplished manually. Data are taken on work sheet forms and reduced at the offices of the Heavy Products Division. Turnaround time for this data reduction is less than 1 day with a maximum of 50 shots of .50 caliber ammunition capable of being handled in any one working day. Also available if required, by means of a high-speed remote terminal at the Research Laboratory, is a CDC-6500 computer located at the U.S. Steel Computer Center.

ANNEX R - INTRODUCTION

OVERVIEW

SwRI (Southwest Research Institute) is a not-for-profit organization devoted to basic and applied research that has been in operation for 26 years. Laboratory facilities and general offices are maintained at 8500 Culebra Road in northwest San Antonio, TX.

The majority of the S/V (survivability/vulnerability) activities at SwRI are concentrated in the Departments of Mechanical Sciences, Materials Sciences, and Structural Engineering. Other departments such as the U.S. Army Fuels and Lubricants and Electronic Systems Research also have some activity in this field. Experiments and analytical programs in the field of S/V conducted by these departments include:

Terminal Ballistics	Electromagnetic Radiation
Gun Dynamics	Modeling
Design of Structures to Suppress Explosions	Blast Loading of Systems and Subsystems
Land Mine Effects	Fuzing
Impulsive Loading	High Pressure Physics
Shock and Vibration	Inhibition of Fuel Fires
Biological and Phychological Effects	

The primary point of contact concerning testing in the SwRI facilities is Mr. Alex B. Wenzel, Manager, Terminal Ballistics and Engineering Dynamics, telephone (512) 684-5111, ext. 2311.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

SwRI performs S/V testing on components of the UH-1B helicopter such as the rotor blades, drive shaft, torque tubes, etc. In addition, the Institute has demonstrated considerable ingenuity in S/V testing of model airborne systems such as response of re-entry vehicles and high altitude missiles to blast loading and blast loads on foreign aircraft inside a shelter.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There are five indoor and three outdoor designated facilities for conducting S/V tests ranging from terminal ballistics, blast loading, shock and impulsive loading, to high temperature and radiation testing. Also, the HE (high explosive) ranges are used for static tests of warheads for obtaining fragment patterns, velocity and mass distribution

information. These facilities are well instrumented with x-ray equipment, high-speed cameras, tape recorders, piezoelectric and piezoresistive transducers, film analyzer, video tape equipment, etc. The indoor and outdoor ballistics and explosive ranges are capable of firing live and/or inert projectiles against live and/or inert targets.

ACCESS

SwRI has excellent access because it is located on the northwest boundary of San Antonio. Road access is through major interstate highway systems (Interstates 10 and 35). Access by air is through the San Antonio International Airport, Kelly, Randolph and Brooks Air Force Bases. Rail access to San Antonio is available through Southern Pacific and MKT Railroads.

MAINTENANCE/FABRICATION CAPABILITY

The SwRI central machine shop produces one-of-a-kind prototypes as well as short production runs. The central shop services include major faiclities for welding, heat treating, machining and quality control. Supplementing the central shop facility are specialized research shops which frequently are staffed for production purposes. The Welding Research Laboratory, for example, has served to supplement the production capability for stainless steel production welding to NASA specifications. Facilities at SwRI which have been used for short production runs to produce prototype hardware for field evaluation include shops for: jewelers precision machining, ultra-fine coil winding, plastic forming, electronic encapsulation, electroplating, strain-transducer bonding, explosive forming, microwave heating, and plastic sealing.

In addition to the SwRI machine shops, the San Antonio area has a wide variety of maintenance and fabrication businesses specializing in machining plastic, fiberglass, aluminum, sheet metal, steel, wood, etc. Also, the maintenance and fabrication facilities of Lackland, Kelly, Randolph and Brooks Air Force Bases and Fort Sam Houston are available.

LOGISTICS SUPPORT CAPABILITY

SwRI possesses the normal logistics capability of a large research organization. In addition, the logistics capability of Kelly, Lackland, Randolph and Brooks Air Force Bases, and Fort Sam Houston, as well as the logistics of the commercial establishments in the San Antonio region can be drawn on.

Several ordnance storage bunkers exist on the Institute grounds and on the off-site ballistic ranges.

INDOOR FACILITIES

TBL (TERMINAL BALLISTIC LABORATORY)

Dimensions

The TBL is a multipurpose indoor/outdoor facility utilized as an explosives and ballistics range facility. Current firings are primarily conducted at ranges of less than 100 feet in a tunnel that is 10-feet-high by 18-feet-wide by 40-feet-deep. Though easily accessible, it is located several hundred yards from the center of the Institute complex.

Weapons/Projectiles Available

The TBL range facilities have been previously used for diversified experimentation with a variety of weapons ranging from .22 caliber (5.56-mm) up to 57-mm projectiles. Through the use of smooth-bore barrels, long rods and irregular shape projectiles have also been tested for exterior and terminal ballistic effects. Explosively launched projectiles such as flyer plates, shaped charges and HEI (high explosive incendiary) ammunition tests against explosive and flammable targets are also conducted in this facility.

Environment

There is no overall capability for environmental control. However, by special design of the target or impact chambers, environmental control of the target environment has been conducted for temperatures ranging from -200°F up to +200°F.

Live/Inert Fire

This facility is capable of firing live or inert projectiles against live or inert targets. HEI ammunition against fuel target tests have been conducted in the TBL.

Safety (and Security) Requirements

SwRI has a Top Secret Facility Clearance, and classified materials and equipment can be accommodated. The TBL has been built according to State and Federal safety regulations and has been approved for ballistic and explosive testing by the U.S. Army Ballistic Research Laboratories Safety Office and cognizant DCASR office. All safety related functions are controlled from the control/instrumentation room. Warning lights and sirens are installed for safety purposes.

Power Availability

220 volts, 3-phase power and standard 110 volts commercial power are available in the instrumentation room and firing chambers. There are approximately 15 kW of power available to the facility.

Observation/Communication

Telephones, as well as an indoor/outdoor intercom system, are available throughout the facility. Firing ranges are evacuated for firings.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A number of make or break circuits screens to measure velocities or trigger the x-ray units are used for ballistic applications.

TIMING. Timing is provided by electronic counter chronographs to ±0.1 μsec accuracy.

HARDWIRE/TELEMETRY. The TBL has available two instrumentation tape recorders, the Ampex FR-1800-L and the Ampex FR-1900. The former is equipped with 14 channels of LS-100 electronics allowing DC to 20 kHz record and replay capabilities with S/N 40 dB. This is considered an intermediate band FM system. The FR-1900 tape recorder is equipped with 14 channels with Wideband II electronics and high frequency record-reproduce heads allowing DC to 500 kHz record and replay capability for S/N 25 dB. The 1900 is one of the latest high frequency tape recorder systems offered by Ampex. Both tape recorders have been frequently used for on-site testing, tape dubbing, and statistical data analysis of existing tapes. A considerable amount of DC electronics is also available for these tape recorders in the event higher frequency capability should be needed.

TBL utilizes a variety of transducers to measure pressure, acceleration, stress-strain, etc. These include manganin gages, Atlantic LC-33, Susquehanna ST4, and various models of Kistler pressure transducers, Endevco, Kistler and Statham accelerometers, and a complete spectrum of strain gages and associated amplifiers and equipment. Transducer calibration is carried out in-house with the use of our shaker systems, shock tube, TBL designed pressure-calibration equipment, load frames, and similar devices. TBL has transducers which have been designed and built for special purposes. In addition, TBL has a number of circuits which have been specially designed for the function of matching transducers and associated equipment would cover a wide range of applications, but we have and could design other such apparatus for special test requirements.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The TBL is equipped with six channels of x-ray. Four (180 kV) channels have orthogonal capability, and the other two (150 kV) are single-channel units. The TBL is also equipped with its own darkroom for processing and developing x-ray film.

The TBL has a high-speed camera capable of 11,000 frames/sec. An Electronic Time Delay Generator is available with three channels of 1000 to 10,000 μsec delays in each channel. A single-sweep trigger lockout device ensures against inadvertent multiple sweeps that can obscure valuable data. For time sequencing greater than 10 μsec, a cam trigger is available that can program a multitude of events from several milliseconds up to several seconds. This device possesses enough amperage capacity to supply the high-speed camera which comes equipped with fail-safe lockouts. Other high-speed framing cameras of this type are available at the Institute. Associated with these cameras we have film viewers and editors as well as developing equipment.

TIMING. Timing is provided by counter chronographs with ±0.1 μsec accuracy.

HARDWIRE/TELEMETRY. TBL has available numerous oscilloscopes and scope plug-in units, many with special capabilities such as dual beam, variable time delay, memory display, 4-channel chopped display, etc. Banks of such scopes have been used in conjunction with available C-30A scope cameras in obtaining multichannel, time-coherent records of data such as blast parameter measurements about the muzzles of small arms, stress-time strain-time measurement in dynamically loaded materials, impulse simultaneity measurements in blast-loaded structures, etc.

For the simultaneous recording of multiple events in a time-coherent fashion where frequency response in the low frequency acoustic range (below 5 kHz) is sufficient, a number of oscillographs and strip chart recorders are available. These include a 17- and a 36-channel CEC Recording Oscillograph with associated galvanometers (for a number of frequency ranges), as well as CEC Galvo Driver Circuits, a CEC 18-channel direct print oscillograph, a Miller type "W" oscillograph, and all necessary record processing equipment. Additional oscillographs are available if a greater number of channels are required. In addition to oscillographs, we have a wide spectrum of recorders including 2- and 6-channel Sanborn pen-recorders, Moseley X-Y recorders, etc. The Sanborn recorders have been used to record displacement-time histories of ballistic pendulums during ballistics testing.

SwRI has a Gerber Digital Data Reduction System Model GDDRS-3B which has been used to analyze oscillograph traces, oscilloscope pictures and other analog data records. It will read to 10^{-2} inch. Its output is punched cards in a format chosen by the operator. These cards are punched out on an IBM punch card device associated with the Gerber which allows for additional data to be punched on each card if desired, as well as the automatic record read-out. SwRI has a Vanguard Motion Analyzer for analyzing high-speed film. TBL personnel have considerable experience in the reduction of data from records both through the use of such equipment and with batteries of human data reducers.

To obtain terminal ballistics data where the target is placed under load prior to impact, a 200,000-pound, closed-loop controlled, hydraulic testing machine is available for this application. The biaxial machine is capable of applying loading along the vertical and horizontal axes.

ILL (IMPULSIVE LOADING LABORATORY)

Dimensions

The ILL was specifically designed for the application of light-sensitive, sprayed explosive techniques for impulsive loading of large structures requiring high-order simultaneity, as well as constant and cosine or cosine-square varying impulses. The primary facility is a 1000 ft^2 laboratory containing two test cells, a combined control and instrumentation room, and a room for manufacturing explosives. This facility is also used for makeup of small conventional explosive charges, and subscale explosive testing. Vulnerability blast studies of a model of a foreign aircraft in a hangar were conducted in this facility.

Weapons/Projectiles Available

Light-sensitive explosives such as SASN (silver acetylide-silver nitrate) are manufactured and tested in this facility. The facility can also accommodate small arms firings up to .30 caliber. Testing of fuzes, primers and sensitivity studies of propellants and explosives are conducted in this facility.

Environment

Facility has controls for temperature and humidity.

Live/Inert Fire

Live projectiles up to 1/8-pound TNT equivalent and inert projectiles can be fired. Makeup of sheet explosive and miniature explosive charges is possible.

Safety (and Security) Requirements

Because of the hazard of the light-sensitive explosives, stringent safety regulations are followed in this facility. Classified materials, targets and equipment are handled. All firings are conducted remotely from the control room.

Power Availability

220 volts, 3-phase and standard 110 volts commercial power are available.

Observation/Communication

CCTV (closed circuit television) coverage is available for tests in either of the test cells. Telephone communications are available.

Instrumentation

In addition to the instrumentation quoted for the TBL, this facility is also equipped with ballistic pendulums for measurement of total impulses. Also, for sensitivity and heats of explosion measurements this facility is equipped with:

1. Impact Drop Test Equipment
2. Friction Sensitivity Equipment
3. Spark Sensitivity Equipment
4. Series 1300 Parr Bomb Calorimeter with the Parr 1104 High Pressure Bomb.

OUTDOOR FACILITIES

TBL (TERMINAL BALLISTICS LABORATORY)

Dimensions

The TBL is a multipurpose indoor-outdoor range utilized as an explosive and ballistic range facility. The range is at least 900-feet-deep without obstruction. The facility is used for obtaining exterior and terminal ballistics information, gun dynamics, blast loading of structures, muzzle blast, effects of landmines, hypervelocity impact using explosive projection techniques, explosive forming, vulnerability of fuel targets, effects of gaseous explosions, etc. Firings requiring ranges greater than 900 feet but not exceeding 1500 feet can be accommodated with some modification to the existing range.

Weapons/Projectiles Available

This facility is capable of firing from 5.56- up to 57-mm projectiles and 0.5-inch rockets. The weapons systems for the larger calibers as well as the projectiles are government furnished. The facility has a 3-pound limit for HE work. For larger quantities of explosives or projectiles, other outdoor facilities are available.

Environment

There is no overall capability for environmental control. Specific control of the environment around the target can be accomplished by special design in accordance with the program needs.

Live/Inert Fire

This facility is capable of firing live or inert projectiles against live or inert targets.

Safety (and Security) Requirements

SwRI has a Top Secret Facility Clearance, and classified materials and equipment can be accommodated. As it was the case for the indoor facility, the TBL outdoor facilities have been approved for ballistic and explosive testing by the U.S. Army Ballistic Research Laboratories Safety Office and the cognizant DCASR office. All safety related functions are controlled from the control/instrumentation room. Warning lights and sirens are installed for safety purposes.

Power Availability

220 volts, 3-phase power and standard 110 volts commercial power are available.

Observation/Communication

Telephones, as well as an indoor/outdoor intercom system, are available throughout the facility. Movie cameras for realtime observation as well as video equipment are available when required.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. A number of make or break circuit screens to measure velocities or trigger the x-ray units are used for ballistic applications.

TIMING. Timing is provided by electronic counter chronographs to ±0.1 μsec accuracy.

HARDWIRE/TELEMETRY. The TBL has available two instrumentation tape recorders, the Ampex FR-1800-L and the Ampex FR-1900. The former is equipped with 14 channels of LS-100 electronics allowing DC to 20 kHz record and replay capabilities with S/N 40 dB. This is considered an intermediate band FM system. The FR-1900 tape recorder is equipped with 14 channels with Wideband II electronics and high frequency record-reproduce heads allowing DC to 500 kHz record and replay capability for S/N 25 dB. The 1900 is one of the latest high frequency tape recorder systems offered by Ampex. Both tape recorders have been frequently used for on-site testing, tape dubbing, and statistical data analysis of existing tapes. A considerable amount of DC electronics is also available for these tape recorders in the event higher frequency capability should be needed.

TBL utilizes a variety of transducers to measure pressure, acceleration, stress-strain, etc. These include manganin gages, Atlantic LC-33, Susquehanna ST4, and various models of Kistler pressure transducers, Endevco, Kistler and Statham Accelerometers, and a complete spectrum of strain gages and associated amplifiers and equipment. Transducer calibration is carried out in-house with the use of our shaker systems, shock tube, TBL designed pressure-calibration equipment, load frames, and similar devices. TBL has transducers which have been designed and built for special purposes. In addition, TBL has a number of circuits which have been specially designed for the function of matching transducers and associated equipment would cover a wide range of applications, but we have and could design other such apparatus for special test requirements.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The TBL is equipped with six channels of x-ray. Four (180 kV) channels have orthogonal capability, and the other two (150 kV) are single-channel units. The TBL is also equipped with its own darkroom for processing and developing x-ray film.

The TBL has a high-speed camera capable of 11,000 frames/sec. An Electronic Time Delay Generator is available with three channels of 1000 to 10,000 μsec delays in each channel. A single-sweep trigger lockout device ensures against inadvertent multiple sweeps that can obscure valuable data. For time sequencing greater than 10 μsec, a cam trigger is available that can program a multitude of events from several milliseconds up to several seconds. This device possesses enough amperage capacity to supply the high-speed camera which comes equipped with fail-safe lockouts. Other high-speed framing cameras of this type are available at the Institute. Associated with these cameras we have film viewers and editors as well as developing equipment.

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SwRI has a Gerber Digital Data Reduction System Model GDDRS-3B which has been used to analyze oscillograph traces, oscilloscope pictures and other analog data records. It will be read to 10^{-2} inch. Its output is punched cards in a format chosen by the operator. These cards are punched out on an IBM punch card device associated with the Gerber which allows for additional data to be punched on each card if desired, as well as the automatic record read-out. SwRI has a Vanguard Motion Analyzer for analyzing high-speed film. TBL personnel have considerable experience in the reduction of data from records both through the use of such equipment and with batteries of human data reducers.

To obtain terminal ballistics data where the target is placed under load prior to impact, a 200,000-pound, closed-loop controlled, hydraulic testing machine is available for this application. The biaxial machine is capable of applying loading along the vertical and horizontal axes.

CAMP BULLIS FACILITIES

Dimensions

The Camp Bullis Facility is an outdoor range facility used for explosive and ballistic testing. This is an Army facility controlled by Fort Sam Houston, TX. SwRI has a working arrangement with Camp Bullis to utilize its facilities for government-sponsored projects for firing of large caliber projectiles from artillery weapons to large quantities of explosives. This facility is located 15 miles from SwRI and has an established range area for performing the above mentioned testing. The established ballistic facilities are approximately 500-feet wide by 2000-feet long. However, Camp Bullis has approximately 100 square miles of real estate, and the capability for ranges larger than 2000 feet exists. Special permission from Fort Sam Houston officials is required for ranges in excess of 2000 feet.

Weapons/Projectiles Available

This facility is capable of firing any large caliber projectile which is fired from an artillery weapon system. Camp Bullis officials require that any large caliber projectile fired be stopped safely within the confines of the range. This facility also has the capability of detonating explosive charges up to several hundred pounds of TNT equivalent. All large caliber weapon systems, projectiles and explosive warheads are furnished by the government.

Environment

There is no overall capability for environmental control. Specific control of the environment around the target can be accomplished by special design in accordance with the program needs.

Live/Inert Fire

Both live and inert projectiles can be fired against live or inert targets.

Safety (and Security) Requirements

Camp Bullis, as an Army facility, has local security including Military Police. Classified materials and equipment can be accommodated. Standard government safety regulations for operation of ballistic and explosive ranges are applied.

Power Availability

Because of the open nature of the facility, all data acquisition equipment is housed in mobile trailers controlled by SwRI. 15 kW power generation furnishing 220 volts, 3-phase and 110 volts, 60-cycle power is available.

Observation/Communication

Telephone as well as radio communication is available throughout the facility. Movie cameras for realtime observation as well as video tape equipment are available when needed.

Instrumentation

Same instrumentation is available at this facility as that described for the TBL facilities. The instrumentation is brought from SwRI in mobile trailers. Heavy equipment support such as cranes, forklifts, bulldozers, frontloaders, etc., is available from the Army. Most other heavy equipment commonly needed for these applications is also available in San Antonio.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The data collected at these facilities are in the form of photographs (optical, x-ray, or shadowgraph), oscilloscope traces, analog recordings on magnetic tape, video tape, and high-speed films. These data are either manually reduced or digitized by the Gerber machine. When required, the data are keypunched; storage is available on either disc or magnetic tape.

QUICK-LOOK CAPABILITIES

Photographs are available from 1 minute (test site processings) to 1 day after the test. Data reduction from photographs requires at least 4 hours, depending on the record length and the extent of data to be extracted from the photographs.

PROCESSING

System and Model

SwRI is equipped with two programmable terminals (Data General Super Nova), one high speed and another of moderate speed, used to access computer systems nationwide. The high-speed terminal is used primarily with a CYBER 74 over a dedicated 9600 baud transmission line and gives the staff immediate access to one of the most powerful computer systems available anywhere. However, when the need arises because of unique applications programs available on other computer systems, the moderate speed terminal is used, over shared access transmission lines (2000 to 3600 baud), to give the staff access to different computer systems from coast to coast (e.g., IBM 360/85, Univac 1108 and CDC-6600). This technique is limited only by voice grade transmission line facilities. Numerous teletype terminals throughout the Institute enable the staff to use conversational techniques on several different computer systems having on-line time-sharing. All ADP equipment and services necessary to provide support are readily available on-site.

As the primary off-site facility, the CYBER 74 computer system has hardware capabilities for performing scientific or data processing jobs and includes a 131,072 word memory—each word contains 60 bits. It has a powerful processor and 18 input/output channels connected to 14 peripheral processor which can handle high-speed card readers, high-speed printers, tape drives, large capacity random access discs, plotters and teleprocessing equipment. With this flexibility of input/output devices and an internal processing speed of 100 nsec, the throughput of the system makes routine jobs extremely economical. The Computer Lab's high-speed terminal which will read cards at 600 per minute and print to 1000 lines/min via a high-speed transmission line gives the Institute staff essentially the same kind of access and response that one would have at the computer site.

In addition to the flexible high-speed terminal, SwRI has a Hewlett-Packard HP2100A, 24,000 digital computer.

Language

Because of the flexibility of the SwRI computation system, virtually any major computer language may be used. The following languages are routinely used at this facility:

1. FORTRAN
2. COMPASS
3. COBOL
4. BASIC

This laboratory is a member of VIM (CDC-6600 User's Group) and FOCUS (CDC-3000 User's Group) and has access to these entire user's libraries.

Input/Output Options

1. 9600 baud transmission line (high-speed terminal)
2. 2000 to 3600 baud transmission line (moderate speed terminal)
3. Card readers (600 cpm)
4. Line printers (1200 cpm)

Realtime/Interaction

The HP2005C Realtime Data Acquisition System for SwRI consists of four modules: the Engine Laboratory Data Acquisition System, the Engine Laboratory Software Development System, the HP2019A Data Acquisition Terminal, and the Analog-to-Digital Converter System.

The Engine Laboratory Data Acquisition System is configured around an HP2100A 24,000 digital computer. The system has 800 analog input channels, a disk storage capacity of 2.5 million words, an ASR35 teletype for operator control and system output, a high-speed paper tape reader, a communications line to the software development system with transfer rates up to 34,500 words/sec, and a keyboard/display unit for on-line monitoring of the system.

The Engine Laboratory Software Development System is also configured around an HP2100A 24,000 digital computer. Equipment includes an incremental plotter, a 2.5 million word disk storage unit, two 7-track magnetic tape units, an optical card reader, a high-speed paper tape reader, a high-speed paper tape punch, a 200 line/min line printer, an ASR33 teletype, and a communications line to the data acquisition system.

The 2019 Data Acquisition Terminal is a backup data logger for the Engine Laboratory Data Acquisition System. The terminal will sequentially scan 800 analog input channels and will record the data on a Kennedy 1600A magnetic tape unit at 500 characters/sec write rate, with a 556 BPI density.

The Analog-to-Digital Converter System has been designed to acquire data on line from various SwRI Laboratories and also to convert data on analog magnetic tapes to digital form for processing on the Central Computer System. The system is configured around the HP2100S Digital Computer. All 16 analog inputs are simultaneously sampled and held, then processed, by the HP2310C high-speed data acquisiton subsystem. Mass storage is provided via the HP7970E Tape Unit. The Keyboard/Display Unit is the HP2752A Teleprinter. Software capability is configured around the BCS (Basic Control System) communicating with a Realtime Executive System.

DISTRIBUTION

Turnaround time is highly dependent upon the amount of data to be processed (minimum-realtime). Throughput of the high-speed terminal is 100 nsec.

ANNEX S - INTRODUCTION

OVERVIEW

The Explosive Ordnance Department of the AAI Corporation conducts engineering design and development programs for devices and systems that use explosives or propellants. Specific fields of interest include small arms and major caliber weapons ammunition, cartridge-actuated devices, chemical ordnance, underwater ordnance, and missile components. In support of the engineering staff, and under departmental supervision, are the Ordnance Model Shop, Loading and Assembly Facilities, and Range Testing Facilities.

The AAI Corporation is located in Cockeysville, MD, 7 miles north of Baltimore on Maryland Route 45, on approximately 80 acres. They offer the specialized and precise range instrumentation essential to the development, testing and evaluation of weapon systems and ammunition up to and including 157-mm.

The primary point of contact for use of this facility is Mr. Richard G. Strickland, Manager, Explosive Ordnance Department, telephone 301-666-1400.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The AAI Corporation has facilities for ballistically testing all aircraft systems and subsystems. Small fixed- and rotary-wing aircraft can be accommodated. (Helicopters could land on the plant grounds.) Gelatin blocks are also used for test pilot vulnerability.

SURVIVABILITY/VULNERABILITY OVERVIEW

The AAI Corporation ordnance testing capability includes three indoor ranges (30 and 70 feet, and 100 yards) and three outdoor ranges (three 100 foot ranges). Inert or incendiary projectiles less than 20-mm may be fired inside. HE (high explosive) projectiles up to 57-mm may be fired on the outdoor ranges. A low velocity (under 300 ft/sec) grenade range is also available (400 meters).

ACCESS

Access to the AAI Corporation is by road. The plant is approximately 7 miles north of Interstate 695 and 1 mile west of Interstate 83. Helicopters could be landed on the plant grounds. Baltimore's BWI Airport is 30 miles southwest.

MAINTENANCE/FABRICATION CAPABILITY

Facilities are available for maintenance and fabrication of weapons systems and ammunition, as well as jigs, fixtures, and special range instrumentation.

LOGISTICAL SUPPORT CAPABILITIES

Storage facilities are available for storage of up to 6000 pounds of explosives, propellants, and related ordnance components. Projectiles up to 57-mm can be reloaded.

INDOOR FACILITIES

30-FOOT AND 100-YARD INDOOR RANGES

Dimensions

The 30-foot and 100-yard ranges are located adjacent to one another under AAI's main plant facility. They share a common 15- by 20-foot firing room and adjacent 15- by 20-foot instrumentation room. Another 6- by 6-foot instrumentation room is located at the end of the 100-yard firing lane. The firing lanes are 6 by 6 feet constructed of reinforced concrete. Sand butts are located at the end of each range.

Weapons/Projectiles Available

Mann barrels in all standard calibers up to and including 20-mm are available in addition to many specific weapons of 20-mm or under.

Live/Inert Fire

Ball, AP (armor piercing and API (armor piercing incendiary) projectiles may be fired on these ranges.

Safety (and Security) Requirements

Range safety requirements are available on request. Standard safety procedures, including safety interlocks on range doors are employed.

Power Availability

Power is available at 110, 220 and 440 VAC (60 and 400 cycle). Plant air is also available.

Observation

Tests can be observed directly or via CCTV (closed circuit television).

In-Flight Ballistic Instrumentation

PHOTOGRAPHY. One Fastex Model WF-3 High-Speed Camera (9000 frames/sec), Model K2001-R High-Speed Camera (9000 frames/sec), one Hycam Model K 209 and one Eastman Kodak High-Speed Camera (3000 frames/sec) are available. All have 100-foot

magazines. Two Field Emission Flash X-ray Systems (180 kV) can be used to photograph three orthogonal views. Two microflash units are available as well as multiple oscilloscope cameras.

TIMING. Three T.S.I. Electronic Counters (Model 361A) and three ECI Velocity Computer Chronographs (Model 4010) are used for timing measurements. Standard 1000 light blips/sec are used for camera timing.

HARDWIRE. A Consolidated Electrodynamics Corporation 18-Channel Recorder (Model 5-124) is used for recording. Multiple oscilloscopes are available. Strain, piezo-electric, pressure, thermocouple and sound level measurements may be made.

Terminal Ballistic Instrumentation

All instrumentation used for in-flight ballistic measurements are also used for terminal ballistic measurements.

Environmental Simulation and Measurement

Target materials, weapons, or projectiles may be temperature (and humidity) conditioned from -75 to +260 degrees.

70-FOOT INDOOR RANGE

Dimensions

The 70-Foot Indoor Range is located in the Low Velocity Test Building. The firing tunnel, which is above ground, measures 8 by 8 feet and is constructed of reinforced concrete. Although primarily intended for research and development of grenade ammunition and associated weapon systems, this range can also be utilized for testing small arms. The range terminates in a sand butt with a steel plate behind it. An instrumentation room is adjacent to the firing area.

Weapons/Projectiles Available

High velocity projectiles up to .30 caliber may be fired. Low velocity (300 ft/sec or less) up to 40-mm may be fired.

Live/Inert Fire

Inert or incendiary weapons only may be fired. Additional capabilities of this range are identical to those of the 30-Foot and 100-Yard Indoor Ranges.

OUTDOOR FACILITIES

QUARRY RANGE

Dimensions

Three 100-foot ranges are located in an abandoned quarry. The three ranges are adjacent to one another and are enclosed for the first 70 feet (18-inch steel tube for 30 feet and 8-foot concrete tube for 40 feet). The ranges terminate in a reinforced concrete sand bunker 30 feet wide, 12 feet high and 12 feet deep. A l-ton monorail and forklifts are used for target handling. A building (1000 ft^2) with instrumentation and loading rooms is located behind a revetment. A reinforced concrete tube 12 feet in diameter, 12 feet deep is also available for static detonation of HE ordnance.

Weapons/Projectiles Available

Projectiles up to 8-inch caliber may be fired at this range. Depleted uranium may also be fired at this range.

Live/Inert Fire

AP, incendiary, and HE projectiles may be fired.

Safety (and Security) Requirements

Range safety requirements are available on request. The area is secure (fence and hourly check by patrolling guards).

Power Availability

Power available at the quarry is judged to be adequate for any conceivable test needs.

Observation.

Direct observation of HE tests is not allowed.

In-Flight and Terminal Ballistic Instrumentation

See the *30 Foot and 100 Yard Range* documentation.

Environmental Simulation and Measurement

A temperature conditioning box is located adjacent to the range building (840 ft^3). The box has a 6- by 7-foot door. Materials can be conditioned from -100 to +200 degrees.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

A Vanguard Motion Analyzer (Model M-16) and two Bell and Howell Motion Study Projectors (Model BD) are used for data reduction. Data can be stored on computer card, magnetic tape and disk.

QUICK-LOOK CAPABILITY

High-speed film and x-rays can be processed in less than 30 minutes.

PROCESSING

System and Model

A General Automation 18/30 computer system, an IBM 370/165 computer system and an Interdata Model 70 computer support the testing done on the range. The 18/30 background partition may also be used to communicate with a variety of computer systems such as the IBM 370 family, the CDC-6600 and the Univac 1108 computer systems.

Language

FORTRAN and assembler languages are available on the 18/30. FORTRAN and COBOL are available on the IBM 370.

Input/Output Options

Standard I/O options are available (including time-sharing). In addition, a Tektronics 4014 graphics CRT and a CALCOMP 738 zip-mode plotter are available on the 18/30.

Realtime/Interaction

Time sharing is available on both the 18/30 and 370.

DISTRIBUTION (Turnaround Time)

Turnaround time is immediate on the 18/30 and overnight on the 370.

ANNEX T - INTRODUCTION

OVERVIEW

The Biophysics Division of the Biomedical Laboratory is located at Edgewood Arsenal, MD, approximately 4 miles south of Interstate 95 on Maryland Route 24. The Biophysics Division, whose mission as principal respondent to the Bioresponse to Trauma, Wound Ballistics and allied programs, has been the sole provider of biological data for this program. These data have been used by weapon designers and systems analysis agencies to develop, improve, update, and evaluate weapons and munitions. Principal users of this data have been AMSAA, JTCG/JMEM, TRADOC, weapon designers through DoD, and systems analysis agencies through DoD. During the R&D phases of munitions development programs, the Biophysics Division has been called upon to provide guidance and data through consultation and/or test evaluations.

Additional responsibilities include the test and evaluation of personnel armor and contributing significantly to both military and civilian R&D programs in the development of evaluation criteria for body armor. Other areas of investigation include: less than lethal weaponry (including Soft and Sting RAG), Future Rifle System Candidates, Personal Defense Weapons, Fuel/Air Explosives, LAW, DRAGON, and TOW user hazards in enclosures, effectiveness of the "Hot Nose" concept for 2.75-inch rockets, and numerous other contributions to the national defense effort.

The primary contact for this facility is Mr. Robert R. Ingram, Jr., Chief of Biodynamics Branch, telephone 301-671-3248.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The Biophysics Division is unsurpassed in its ability to test and evaluate the antipersonnel effects of projectiles and fragments and the utility of various types of body armor and other protective equipment.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There are three indoor ranges and two outdoor ranges at this facility in which inert or incendiary projectiles up to 20-mm may be fired. In addition, a grenade range (for detonating small antipersonnel weapons), a 2-inch shock tube, and a flame facility are also available for use. The Biophysics Division also has access to any of the ranges at Aberdeen Proving Ground for tests using HE or projectiles larger than 20-mm.

ACCESS

Primary access to Edgewood Arsenal is by highway via Interstate 95 and Maryland Route 24. Helicopter and light aircraft service is available at Weide Field, Edgewood Arsenal. Heavier aircraft service is available at Phillips Field, Aberdeen Proving Ground which is approximately 12 miles from the Edgewood Arsenal area of Aberdeen Proving Ground.

MAINTENANCE/FABRICATION CAPABILITY

Complete machine shop facilities (including welding) are available.

LOGISTICAL SUPPORT CAPABILITY

Bulk ammunition storage facilities are located on post. Ammunition up to and including .50 caliber can be loaded on site.

INDOOR FACILITIES

MAIN RANGE

Dimensions

The main firing room is 27 by 32 by 11 feet high. The walls are reinforced concrete with a minimum thickness of 8 inches. The room has a 4-inch-thick concrete slab ceiling covered with 2 inches of poured gypsum. A 4-foot-wide lane terminating in the firing room provides the capability of firing up to 18 meters. Projectiles are fired into bullet catchers composed of approximately 7 feet of sand and metal shavings backed with armor plate. A 9- by 22-foot control/instrumentation room and a small loading room are adjacent to the firing room.

WEAPONS/PROJECTILES AVAILABLE

Projectiles up to 20-mm may be fired on this range, Mann barrels from .17 caliber through 20-mm are available in addition to many weapons. Additional weapons may be procured from Aberdeen Proving Ground if required.

Live/Inert Fire

Inert or incendiary projectiles may be fired. Tests with HE projectiles would be conducted at Aberdeen Proving Ground ranges. The Biophysics Division is a tenant activity located at Aberdeen Proving Ground.

Safety (and Security) Requirements

This facility employs safety interlocks on the door to the firing room. Facilities are available for storage of classified materials.

Power Availability

Electrical power required can be provided either through plant facilities or by portable generators.

Observation

Three-inch-thick glass observation ports are provided to observe the target area.

In-Flight Ballistic Instrumentation

All instrumentation used by the Biophysics Division is portable and can be used on any of the ranges (including those at Aberdeen Proving Ground).

PHOTOGRAPHY. The following high-speed cameras are available:

1. Four Redlake Hycam (100 feet) 3800 frames/sec
2. Two Redlake Hycam (400 feet) 11,000 frames/sec
3. Three Dynafax (35-mm split) 32,000 frames/sec
4. One Dynafax (35-mm full frame) 27,000 frames/sec.

Six flash units with controls are available for use with the Dynafax cameras. Single (6) and multiple (10- and 15-channel) microflash units are available for use with still cameras. Spark photography may also be employed.

Multiple x-ray heads (180 and 300 kV) are available for use with either an 8- or 3-channel system, respectively.

TIMING. Both paper grids and light screens are used with chronographs for measuring projectile velocity and actuating instrumentation. Timing marks on camera film can be generated at 10, 100, or 1000 marks per second.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. See *In-Flight Ballistic Instrumentation*.

TIMING. See *In-Flight Ballistic Instrumentation*.

TRANSDUCERS/TELEMETRY. Transducers available include thermocouples and calorimeters for measuring temperature and heat flux, and strain and piezoelectric gages for measuring pressure and acceleration. Equipment for recording transducer signals include a 14-channel, Honeywell Model 96 tape recorder with 500 kHz bandwidth in FM and 2 MHz bandwidth in direct; two 14-channel, Honeywell Model 5600 tape recorders with 40 kHz bandwidth in FM and 300 kHz bandwidth in direct; two Tektronix Model 7633 storage oscilloscopes with 100 MHz bandwidth and 3.5 nsec rise-time; one 12-channel, Honeywell Model 2106 oscilloscope; two 12-channel, Honeywell Model 1508 oscillographs; and one 12-channel Honeywell Model 906 oscillograph. Telemetry equipment, complete physiological monitoring equipment, and an infrared scanner for remote nondestructive thermal evaluation of the target are available in-house. All necessary calibration and test equipment to support the previously listed equipment is in-house. Calibration is traceable through the Edgewood Arsenal Calibration and Metrology Lab to the National Bureau of Standards.

FIRST SUPPLEMENTARY RANGE

Dimensions

This facility is a firing room 18 by 32 feet with ordnance brick walls and a wooden ceiling. Projectiles are fired into bullet catchers composed of approximately 7 feet of sand and metal shavings backed with armor plate. A 30-foot vertical range also terminates in the firing room.

Weapons/Projectiles Available

Projectiles up to .30 caliber may be fired.

Live/Inert Fire

Only inert projectiles may be fired. For additional capabilities see *Main Range* documentation.

SECOND SUPPLEMENTARY RANGE

Dimensions

This facility is a small room measuring 6 by 12 feet. Projectiles are fired into various types of ballistic catchers backed with armor plate.

Weapons/Projectiles Available

This firing range was designed for firing small, low velocity, fragments (maximum of 22 caliber at 1000 ft/sec) and for firing sand, gravel, etc., at transparent armor such as lenses, visors, etc.

Live/Inert Fire

Only inert projectiles may be fired. For additional capabilities, see *Main Range* documentation.

OUTDOOR FACILITIES

500-METER RANGE

Dimensions

This range is an open area with concrete gun mounts located at 100-meter intervals. An Ordnance Trailer containing a gun mount, instrumentation and electrical generator can be used to provide a work area.

Weapons/Projectiles Available

Projectiles up to and including .30 caliber may be fired.

Live/Inert Fire

Inert or incendiary projectiles may be fired.

Safety (and Security) Requirements

Storage of ordnance and materials is provided at the indoor facility.

Power Availability

Power is provided by portable generators.

Observation

Tests may be viewed from behind the gun mount.

Instrumentation

See *Main Range* documentation.

100-METER RANGE

Dimensions

This facility is an open range with concrete gun mounts located at 50 yards, 50 meters, 100 yards, and 100 meters. Projectiles are fired into a backstop composed of earth and armor plate.

Weapons/Projectiles Available

Projectiles up to and including .30 caliber may be fired. For remaining capabilities see the *500-Meter Range* documentation.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

A Telecordex Film Reader is available for reducing data from photographs and high-speed film to punched paper tape. An x-ray reader is also available for reducing x-ray to paper tape.

QUICK-LOOK CAPABILITIES

Black and white film and x-rays can be processed immediately (within 15 minutes). Small amounts of color film may also be processed immediately.

PROCESSING

System and Model

A Univac 1108 (128,000 memory core) is available either in a batch mode (Univac DCT 2000) or in a time-sharing mode.

Language

FORTRAN, COBOL, BASIC, and PL/1 compilers are available in addition to several specialized support packages (including GPSS, SPSS, OMNITAB and BMD).

Input/Output Options

Card, disk, tape (7-track), paper tape, teletype, and Calcomp plotter are included in the I/O options.

Realtime/Interaction

Time-sharing is available.

DISTRIBUTION (TURNAROUND TIME)

Turnaround time on the computer is from 2 minutes to 1 hour, depending on the length of run. B&W film and x-ray can be processed immediately. Small amounts of color film can be processed immediately, but normal processing required 1 to 2 days.

ANNEX U - INTRODUCTION

OVERVIEW

The Boeing Aerospace Company's Impact Mechanics Laboratory is located at the Boeing Plant Number 2 in Seattle, WA. The Tulalip Test Site is just north of Seattle and the Boardman Test Site is in north central Oregon.

These facilities provide ballistic test support for the entire family of Boeing Companies. They are used for the conduct of tests concerning terminal effects, fuel system flame propagation and retardation, and hydraulic ram effects. Figure U-1 shows a hydraulic ram test tank.

The primary point of contact concerning testing in these facilities is Mr. Robert G. Blaisdell, Manager, Impact Mechanics Laboratory, telephone 206-773-9894.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

Boeing performs S/V testing on high performance aircraft, medium performance aircraft, and helicopters. Testing is conducted of full scale complete aircraft, structural components, rotor blades, and fuel systems. The facility has been extensively used for hydraulic ram testing, ullage combustion testing, and fuel vapor testing.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The Impact Mechanics Laboratory has evolved during a decade of studying impact phenomonology ranging from free-fall velocities (10 ft/sec and up) to simulated meteroid impact (up to 32,000 ft/sec). The result of this evolution is a laboratory with an extremely wide capability range operated by personnel with vast experiences in conducting and analyzing impact events. The unique capability of the laboratory centers around test facilities and hardware, interpretation of experimental results, and analysis. Facilities include two highly instrumented powder gun ranges and several hazardous test sites. Included as part of the ranges are highly sophisticated instrumentation such as integrated fire-control, velocity monitor and instrument control systems. This special equipment, built especially for the Impact Mechanics Laboratory, is backed up by high-speed cameras of many types, x-ray equipment, and standard laboratory equipment.

The primary objective of each program conducted in the Impact Mechanics Laboratory is to solve a specific problem in design technique or to understand a particular physical phenomena, and to present the results in analytical, graphical, and pictorial forms. Because of the complexity of projectile-target response, major dependence in obtaining solutions to problems must be placed on experimental evidence. Adequate test data rarely exist; hence, each program usually requires performance of one or more test series. Several facilities are available to Impact Mechanics Laboratory personnel for obtaining experimental data. These include two indoor ranges and two outdoor hazardous test facilities.

ACCESS

Excellent access to the Boeing facility is provided by Interstate 5, the port of Seattle and the Boeing airfield which is adjacent to Plant Number 2. Seattle/Tacoma International Airport is approximately 5 miles south of the facility via Highway 99. Rail access is provided by a spur of the Burlington Northern on the plant grounds.

MAINTENANCE/FABRICATION CAPABILITY

Complete machine shops and maintenance facilities are available for the fabrication or support of virtually any mechanical or electronic systems.

LOGISTICS SUPPORT CAPABILITY

The logistics support normally associated with a large manufacturing facility is available to the laboratory. Ammunition storage is available at the indoor range for up to 1 week's needs (nominally 40 rounds of 20- or 40-mm, 200 rounds of .30 or .50 caliber). Complete precision loading support is provided by the Boeing Ordnance Laboratory. The Tulalip site has Class A storage facilities for virtually unlimited quantities of hazardous materials.

INDOOR FACILITIES

DIMENSIONS

The Impact Mechanics Laboratory occupies over 6500 ft^2 arranged as shown in Figure U-2. Test firings are normally conducted over a range of a few feet. Figures U-3 and U-4 are photographs of the two indoor ranges.

WEAPONS/PROJECTILES AVAILABLE

Military Bullet Launchers

Launchers are available with rifled bores of .22, .30, .303, and .50 caliber and 7.62, 12.5, 14.5, 20, and 40 mm. These include complete military guns and special barrels with adjustable breeches. The adjustable breeches allow any of the barrels to be charged by standard .30 or .50 caliber or 20-mm powder cases. For certain applications, smooth-bore barrels are also available. Various barrel lengths are available from standard military length down to 1 inch. For especially low velocities, air-launch equipment is available.

Fragment Launchers

Many fragment types have been launched, from MIL-P-46593 (Ord) fragment simulators to special spheres, rods, cubes, cylinders, and flechettes. The fragment simulators are launched from the rifled-bore guns described above. The special fragments require sabots and are launched from smooth-bore barrels fitted with the special breeches described above. Smooth-bore barrels are available in .30, .50, and .60 caliber, 20-mm, and 1/2, 7/8, 1, 1-1/4, 2-1/4, 2-1/2, 3-1/2, and 4-1/2 inches in diameter. A special capability has been developed for multiple fragment impacts. Any number of fragments can be launched in any desired pattern.

Special Launch Capability

Many programs have been conducted where special particles were required to be made to impact targets. When each requirement became known, special techniques were developed. Following are the results of some of these developments.

ROCK IMPACT. Actual rocks, varying in size from dust to 3 inches in diameter, have been launched from a few ft/sec to 7000 ft/sec. The rocks have included basalt, granite, and quartz of various shapes and specially ground granite cylinders. Simulated rocks consisting of glass spheres have also been used.

SIMULATED HAIL. Techniques have been developed to launch spherical ice balls from 1/4 to 2 inches in diameter at velocites up to over 4000 ft/sec.

RAIN DROPS. Single and multiple rain drops can be launched in sizes ranging from 1.0 to 3.5 mm in diameter at up to 5000 ft/sec.

INSTRUMENTED PROJECTILES. The capability has been developed to launch projectiles with on-board transducer and telemetry systems. These projectiles have been fired as small as .50 caliber diameter. Applications for these projectiles are in-flight temperature, ablation rates, and decelerations.

Table U-1 shows projectile weights which can be launched at each Boeing facility.

ENVIRONMENT

Test specimens may be subjected to heating to temperatures of up to 3000°F by quartz lamps, cooling to -120°F by liquid nitrogen or to simulated altitudes of up to 2 microns of Hg during test firings. Oxygen rich environments have also been simulated. Specimens may be loaded to 3,000,000 pounds by special loading frames.

LIVE/INERT FIRE

Only inert projectiles or incendiary can be fired in this facility. Projectiles of up to 40-mm armor-piercing incendiary can be fired.

SAFETY (and SECURITY) REQUIREMENTS

The Impact Mechanics Laboratory holds a facility clearance to the SECRET level and has storage capacity for documents and materiel of that classification.

All testing is conducted in accordance with approved safety procedures. Electronic or mechanical interlocks prevent firing until the range area is clear and a safety release is given by the range master.

POWER AVAILABILITY

Single-phase and 3-phase electrical power of 100, 220, and 440 VAC is available on the range. Hydraulic power is provided by one of three portable rigs, two provide pressures to 5000 psi and one to 3000 psi.

OBSERVATION/COMMUNICATION

Direct visual observation is available through use of an optical periscope. Realtime observation of tests is also available through a closed circuit television system.

A public address system provides communications on the range.

IN-FLIGHT BALLISTIC INSTRUMENTATION

Laser/Photography

In addition to standard still and motion picture cameras, the laboratory is equipped with a number of cameras especially suited for the study of impact phenomena. An Abtronics image-converter camera is available for the study of very high-speed events. Single frames can be taken at exposure times of down to 5 nsec. For very high-speed multiple-frame photography, a B&W Kerrcell camera is available with a framing rate of up to 2 by 10^8 frames/sec. Very high quality single-frame photographs are possible with open shutter/strobe light systems. Standard 16-mm movies are taken at up to 11,000 frames/sec; split-frame movies are taken at up to 44,000 frames/sec. X-ray photography is possible with a three-headed 300 kV Field Emission Unit.

A built-in feature of the control system allows high-speed motion picture cameras to control the firing time. After the cameras have reached a predetermined framing speed, a signal is generated that activates the launcher.

Timing

The prime velocity measuring system is composed of photomultiplier/light source stations connected to a counter. A lens and slit arrangement with a fast response photomultiplier tube assures dependable and accurate velocity measurement. When required, make/break screen velocity station units are also available.

In addition to readout on a counter, the velocity station signals are fed to a special computer. The computer calculates and reads out the velocity and determines the time-of-flight of the projectile to a particular point in the target area. At the proper time, the computer generates a control signal to trigger data acquisition equipment such as cameras or oscilloscopes. The point in space is preselected and fed manually into the computer prior to the test. Accuracy of the computer is such that triggering of instrumentation can be obtained when the projectile is within 0.03-inch of the desired location. Several computers are available with up to five independent channels.

Hardwire/Telemetry

All control and data acquisition instrumentation on this range is hardwired.

TERMINAL BALLISTIC INSTRUMENTATION

Laser/Photography

The photographic and x-ray equipment described above are also used to acquire data concerning terminal effects.

Timing

The timing system described above is used to measure and control events associated with terminal effects.

Hardwire/Telemetry

Systems are available to conduct a large number of impact measurements, including pressure, strain, temperature, acceleration, velocity, heat, light intensity, and loads. Where commercially available, equipment has been obtained that will provide analog records of the above phenomena during short duration impacts (in the μsec region). Where short-term measuring and recording equipment was not available, special equipment has been developed within the laboratory. For example, most commercial high-speed load cells have a rise-time of about 10 msec and have small tensile capability compared to compression. A load cell was fabricated within the laboratory with a 5-μsec rise-time and a tensile equal to its compressive capability.

The laboratory contains a great deal of standard diagnostic equipment. Of special interest to impact studies are mass balances, a Brenell hardness tester, and a metallurgical microscope.

OUTDOOR FACILITIES

TULALIP TEST SITE

Dimensions

Testing too hazardous to conduct near a populated area is performed at the Tulalip Test Site, located north of Seattle. The 2200-acre site has 26,000 ft^2 of enclosed laboratories, office space, and shop support buildings. The test areas consist of 10 revetments and 20 bunkers. Figure U-5 is a plan view of Tulalip Test Site. A portion of the site is used for tests to determine fuel tank rupture and fire initiation conditions. Three test cells and a 10,000-gallon sump tank are available for ballistic tests of fuel tanks. Other areas are used for explosive device testing and structural survivability tests.

Figure U-6 shows one of the revetments used for gunfire tests of a fuel system. Figure U-7 shows the panel used to control and monitor the Figure U-6 test. Figure U-8 shows a loading frame for stressed specimen tests.

Weapons/Projectiles Available

All the weapons and projectiles listed for the Impact Mechanics Laboratory can be used on this site.

Environment

All testing at this site is conducted under ambient conditions except that specimens may be stressed up to 3,000,000 pounds in tension and 250,000 pounds in compression.

Live/Inert Fire

Live projectiles weighing up to 10 pounds can be fired at this site. High explosive rounds up to 6 inches in diameter have been fired.

Safety (and Security) Requirements

Projects with classification up to the SECRET level can be accommodated.

The test site is completely enclosed with security fencing which limits access by unauthorized personnel.

Complete fire protection is available on site for use in fuel system testing.

A warning light system is used to alert personnel in the area during testing.

Power Availability

Commercial electric power of 110, 220, and 440 VAC in both single- and 3-phase modes is available.

Observation/Communication

Realtime observation of tests is available through closed circuit television.

Range communications are provided by both telephone and radio networks.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. All the photographic equipment described above can be used at this site.

TIMING. Velocity screens can be used in conjunction with the Beckman 210 Data System for measuring projectile velocities.

HARDWIRE/TELEMETRY. All instrumentation is hardwired to a Beckman 210 Data System which can handle up to 180 channels of analog data.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The photographic equipment previously described can be used at this site.

TIMING. The Beckman 210 Data System in conjunction with appropriate sensors can provide time data concerning terminal events.

HARDWIRE/TELEMETRY. All measurement and recording instrumentation is hardwired into the central data system.

BOARDMAN TEST SITE

The Boardman Test Site in North Central Oregon is used for tests of rocket and jet engines, of very large explosive charges, and where extremely long flight ranges or separation distances are needed. Air space above the site is controlled up to an altitude of 23,000 feet.

Since this site does not include permanent installations, all instrumentation and test articles must be moved there from other sites.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The data collected in these facilities are in the form of photographs, oscilloscope traces, analog recordings on magnetic tape, video tape, and high-speed films. These data are normally manually reduced and stored in hard copy. The capability for on-line computer recording and analysis exists if required.

QUICK-LOOK CAPABILITY

Photographic data are usually available within 24 hours. Other data are available within a few minutes after each test.

PROCESSING

Data are normally processed manually. A complete range of high-speed cameras is available if required.

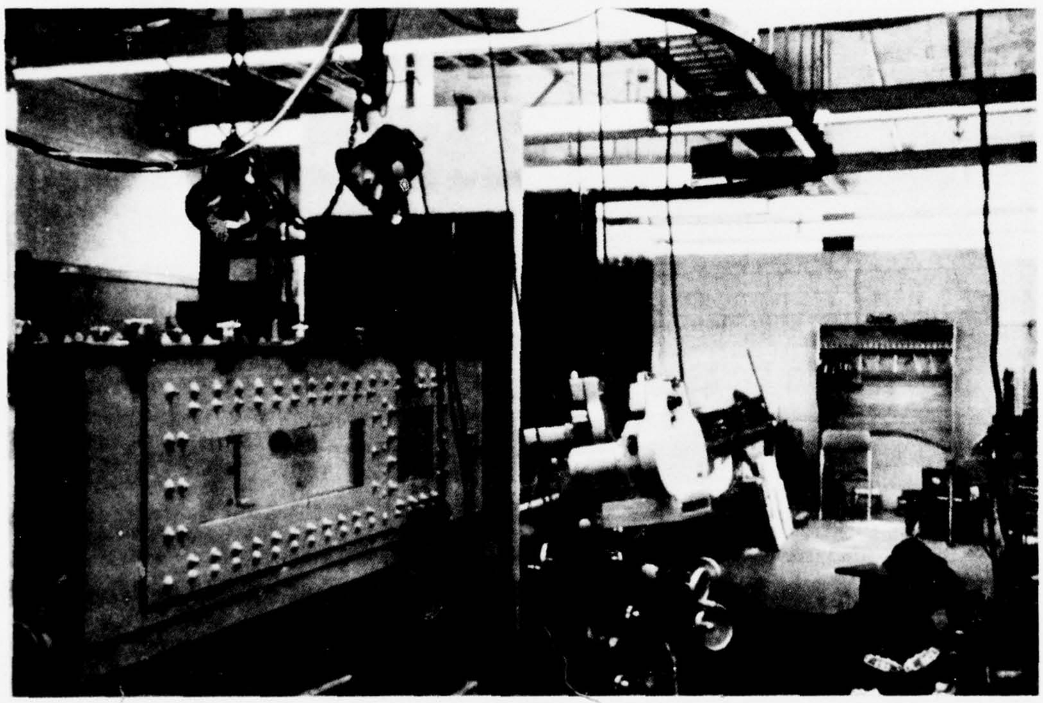

Figure U-1. Hydraulic Ram Test Tank.

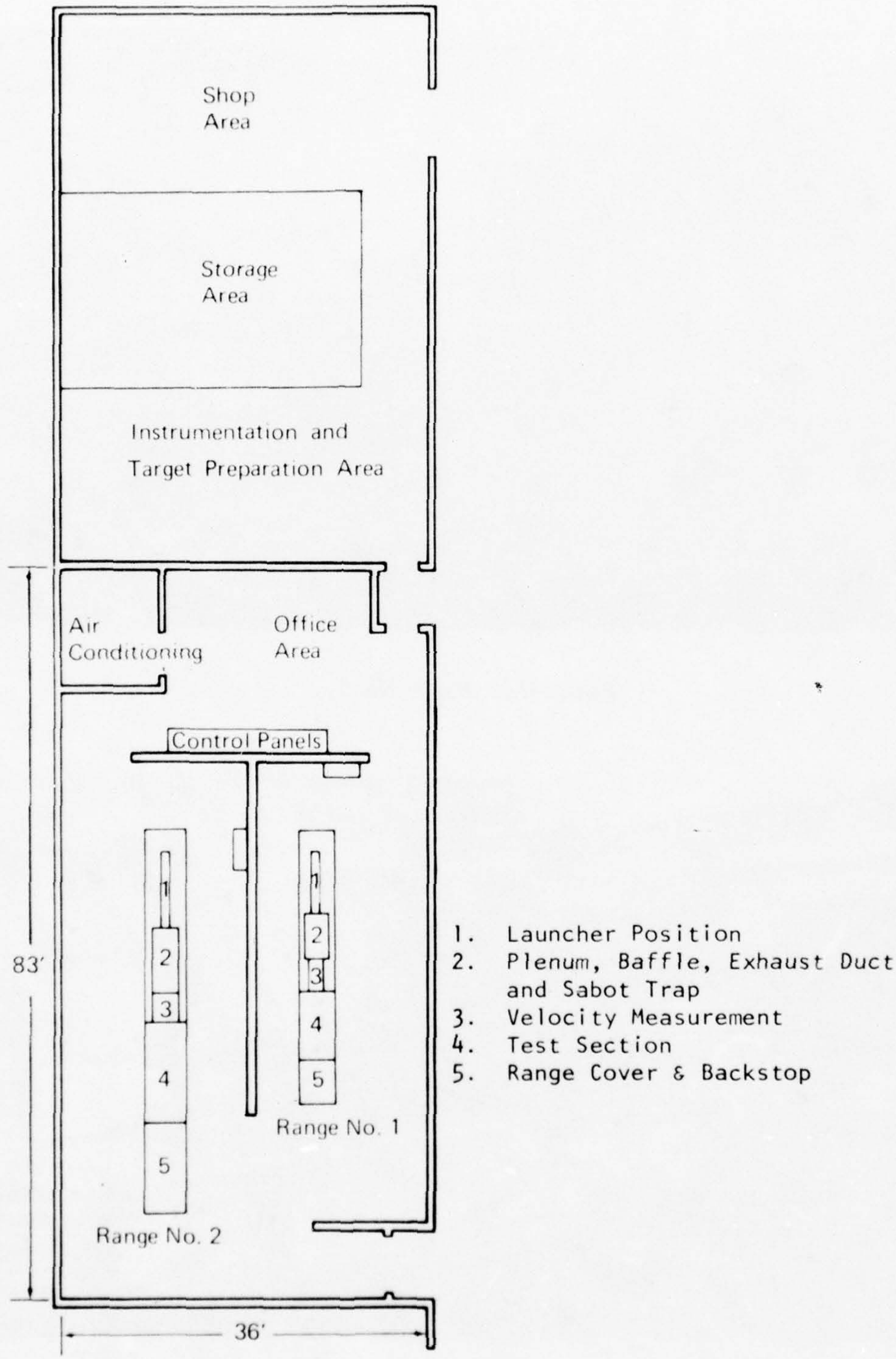

Figure U-2. Impact Mechanics Laboratory - Floor Plan.

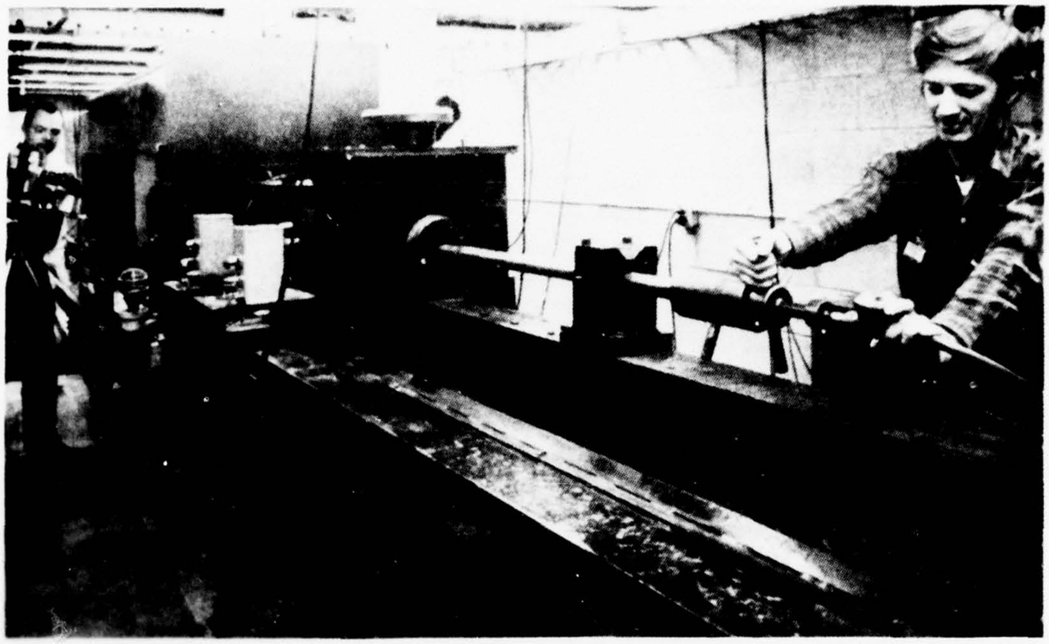

Figure U-3. Range No. 1.

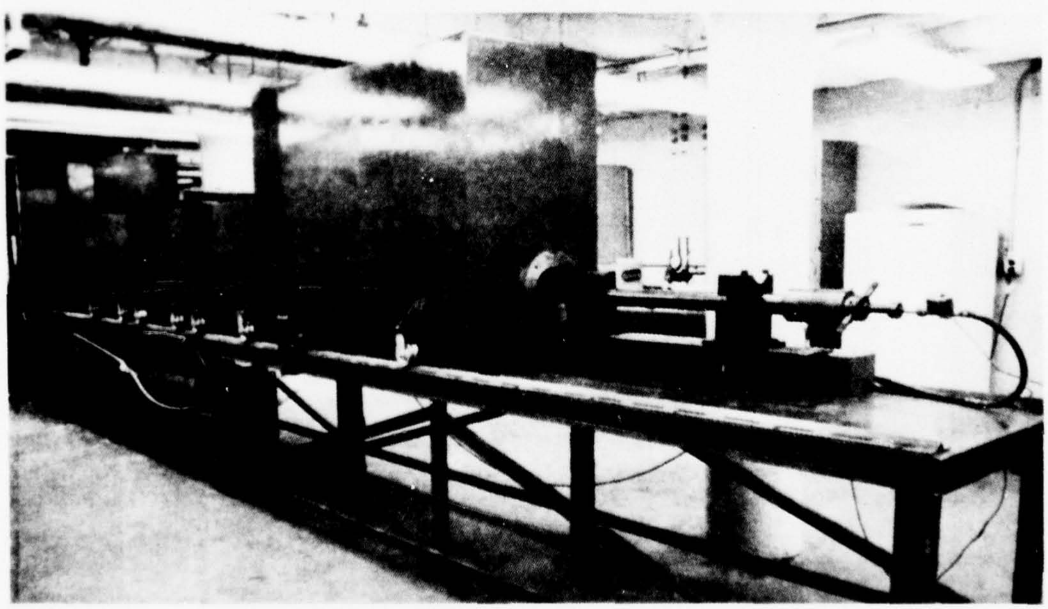

Figure U-4. Range No. 2.

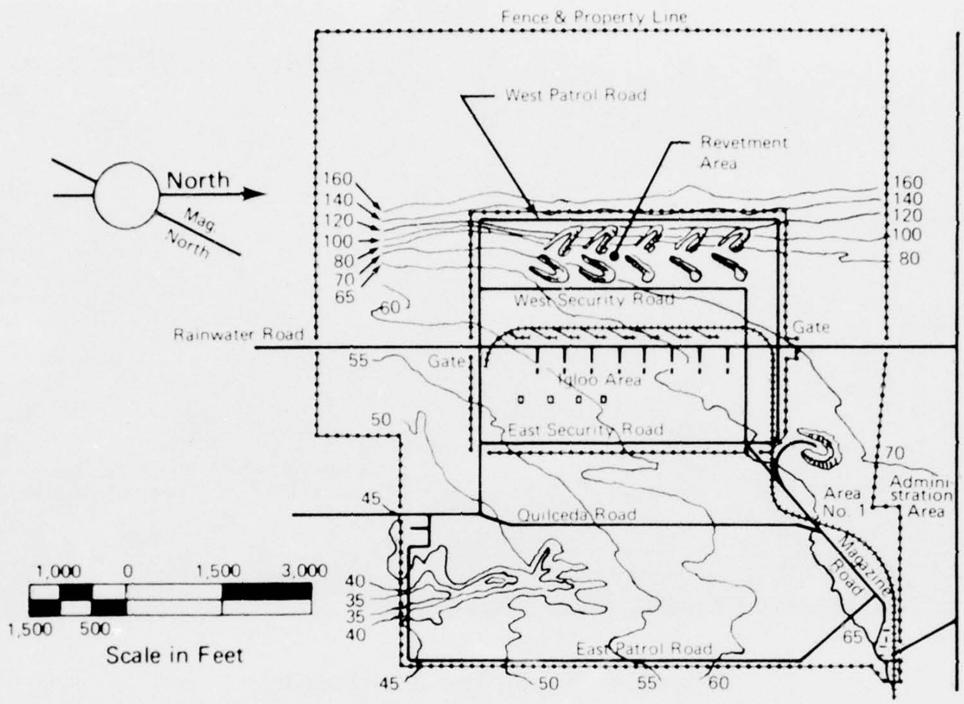

Figure U-5. Talalip Test Site Plot Plan.

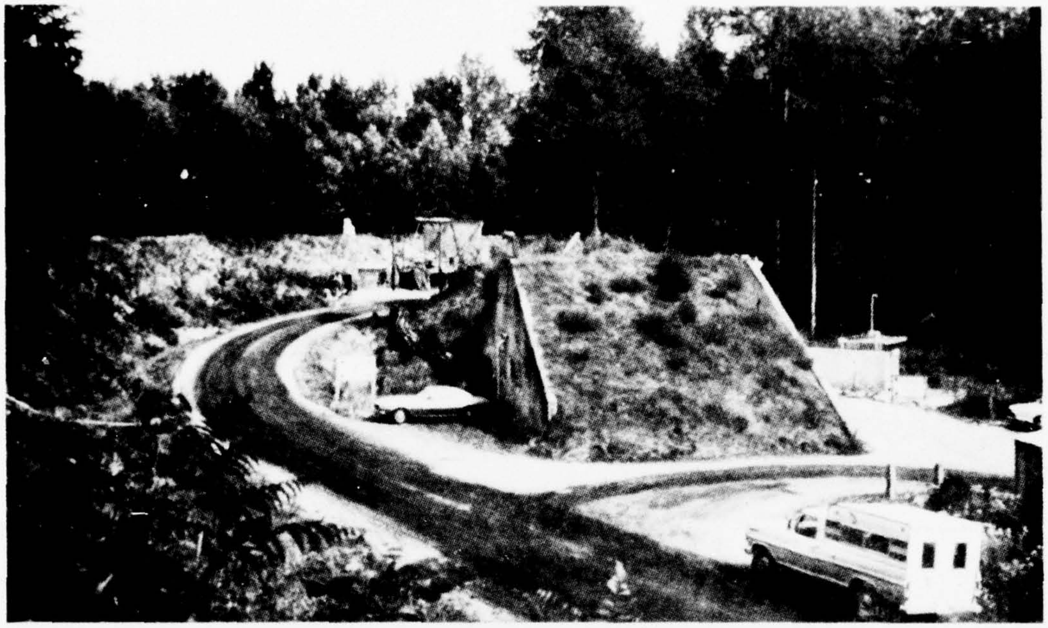

Figure U-6. Tulalip Test Site - Area 1.

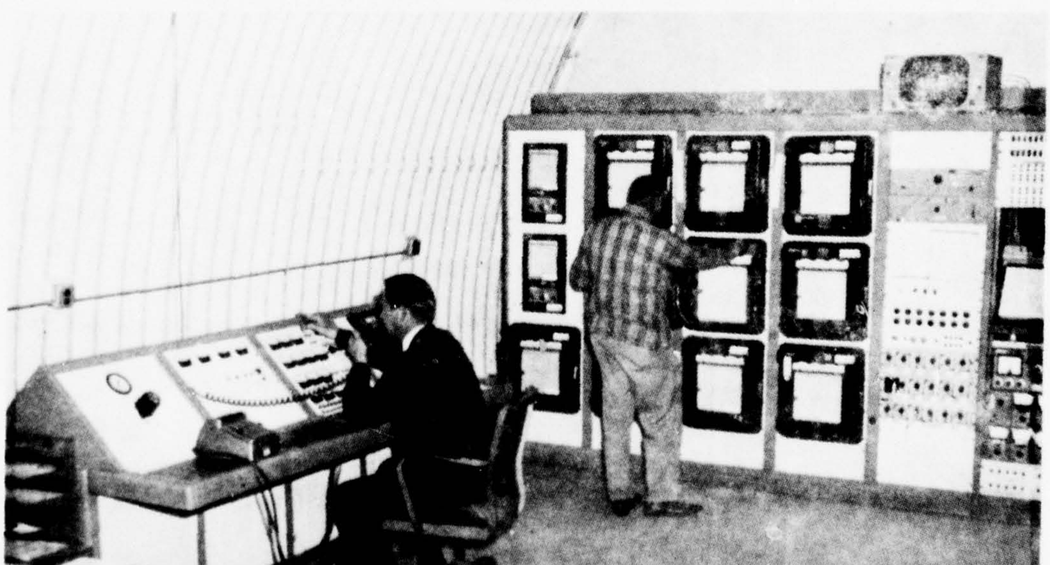

Figure U-7. Fuel System Control Console.

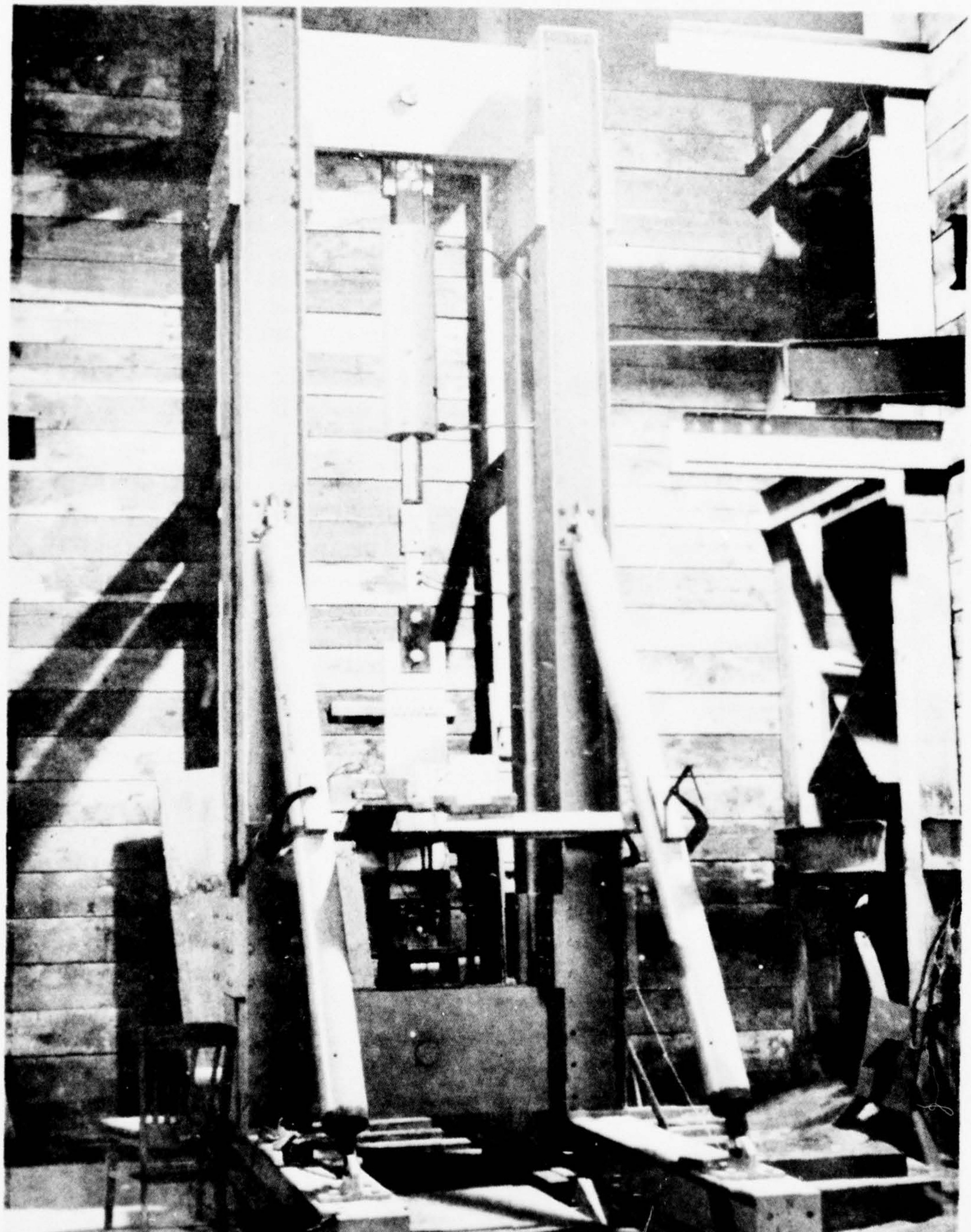

Figure U-8. Three-Million-Pound Loading Frame.

Table U-1. Impact Mechanics Laboratory Test Ranges.

Range	Velocity range, ft/sec	Projectile range, lb	Typical tests
Impact Mechanics Laboratory Range No. 1	Up to 7500	Up to 5	Structural Survivability Fuel System Survivability Biological Tissue Impact Rain Impact Hail Damage Rock Impact Component Survivability
Impact Mechanics Laboratory Range No. 2	Up to 7500	Up to 5	Structural Survivability Fuel System Survivability Biological Tissue Impact Rain Impact Hail Damage Rock Impact Component Survivability Stressed Targets
Tulalip Test Site	Up to 10,000	Up to 10	Large Explosive Tests Gunfire Tests of Complete Fuel Systems Rocket Engine Tests Fuel Impact Tests

ANNEX V - INTRODUCTION

OVERVIEW

The Boeing Company's Vertol Division facilities provide extensive capability for the development and production of aircraft (primarily helicopters) and aircraft systems. The operational personnel at the ballistic test facility at Vertol Division have been trained and qualified by Development and Proof Services, Division of Aberdeen Proving Ground and the facility is certified by the U.S. Government. In addition, facilities support is available, as required, from other Boeing Company divisions throughout the United States. Aircraft developed by the Vertol Division include the HUP, H-21, CH-46, and CH-47 helicopters. Vertol Division is presently flight testing the YUH-61A U.S. Army UTTAS helicopter. The primary point of contact for this facility is Mr. Earl Riegner, telephone 215-522-7960.

GENERIC AIRCRAFT SYSTEMS TESTED

Material, components, structure sections, self-sealing fuel lines (but not fuel cells), and, in general, all aircraft components which can be fit in the 6-foot-wide, 8-foot-long, 12-foot-high test cell and which do not represent a significant fire or explosive hazard, can be ballistically tested.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The ballistic test facility at the Boeing Vertol Division is an 80-foot-long tunnel (4 by 8 feet) in which up to 20-mm AP or API ammunition can be fired.

ACCESS

The Boeing Vertol Division test facility is located at the Division's production facilities on Stewart Avenue, Ridley Park, PA, approximately 5 miles south of Philadelphia. The facility is adjacent to Interstate Route 95 and has rail transporation to the production facilities. The plant is approximately 3 miles from the airport and can accommodate helicopters landing on the grounds.

MAINTENANCE/FABRICATION CAPABILITIES

Facilities for maintenance, fabrication, and repair of all aircraft systems is excellent.

LOGISTICAL SUPPORT CAPABILITY

Logistical support capability for aircraft systems is excellent. Ammunition and powder storage facilities are available, in addition to an ammunition downloading facility.

INDOOR FACILITIES

BALLISTIC TEST FACILITY

Dimensions

The layout of the Boeing Vertol Division ballistic test facility is shown in Figure V-1. The firing lane is an underground tunnel 4 feet wide and 8 feet high. A removable backstop is installed approximately 70 feet from the backstop. With the backstop removed, targets may be placed in a test cell 6- by 8- by 12-feet high (through an access cover) immediately behind the usual position of the backstop. A Frankford gun mount is installed behind steel blast doors uprange.

Weapons/Projectiles Available

Projectiles up to 20-mm may be fired. Weapons are available for firing .223, .30, and .50 caliber; 7.62-, 14.5-, and 20-mm projectiles.

Live/Inert Fire

Ball, AP and API projectiles may be fired. No live HE projectiles may be fired.

Safety (and Security) Requirements

The test facility is secure. Range safety requirements are available upon request.

Power Availability

Electrical power is available at the range at 110, 220, and 440 VAC. Standard aircraft electrical and hydraulic power can be made available with generating units.

Observation

No live observation of tests is allowed. The tunnel is cleared of personnel before each test.

In-Flight Ballistic Instrumentation

An instrumentation/personnel trailer is located above ground adjacent to the tunnel range. All instrumentation not required to be physically in the tunnel is located in the trailer.

PHOTOGRAPHY. Little in-flight photography is usually done; however, high-speed cameras used for terminal effects can be used for in-flight recording if desired.

TIMING. Timing measurements are usually oriented toward actuation of instrumentation consistent with projectile time of arrival. The instrumentation consists of either a photomultiplier station or make/break screens to measure velocity.

Terminal Ballistic Instrumentation

PHOTOGRAPHIC. Four Redlake Hycam high speed cameras with framing rates up to 44,000 frames/sec and a B&W Fastex camera with a framing rate up to 8500 frames/sec are used for high-speed photographs of tests.

TIMING. A photomultiplier station or make/break screens are used to measure projectile velocity. Signal, counter, and synchronization amplifiers are used with an event sequencing computer and an integrated fire control system to initiate recording consistent with projectile time of arrival.

HARDWIRE/TELEMETRY. Shock accelerometers, strain, pressure, temperature, and acoustical level transducer measurements may be recorded on oscillograph or various types of strip charts.

Environmental Simulation and Measurement

Target specimens (including fuel in self-sealing fuel lines) may be temperature-conditioned from -65 to +160 degrees.

OUTDOOR FACILITIES

There are no outdoor facilities at Boeing Vertol.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data may be stored in computer card, tape, disk, or computer generated plots using facilities provided by Boeing Computer Services, Inc.

QUICK-LOOK CAPABILITIES

Data recorded on oscillograph or strip chart recorders are available immediately. Photographs can be made available within 2 hours with in-plant processing of film. Computer data reduction can be done with immediate turnaround time.

PROCESSING

System and Model

Boeing Computer Services, Inc., provides computer data processing services in either a time-sharing or remote batch mode. IBM 360/65 and IBM 370/158 systems are available.

Language

All languages consistent with the IBM processors are supported in addition to a wide array of support packages.

Input/Output Options

All common I/O options are provided, including Calcomp plotting.

Realtime Interaction

Time-sharing mode is available on either system.

DISTRIBUTION (TURNAROUND TIME)

In most cases, turnaround time is almost immediate.

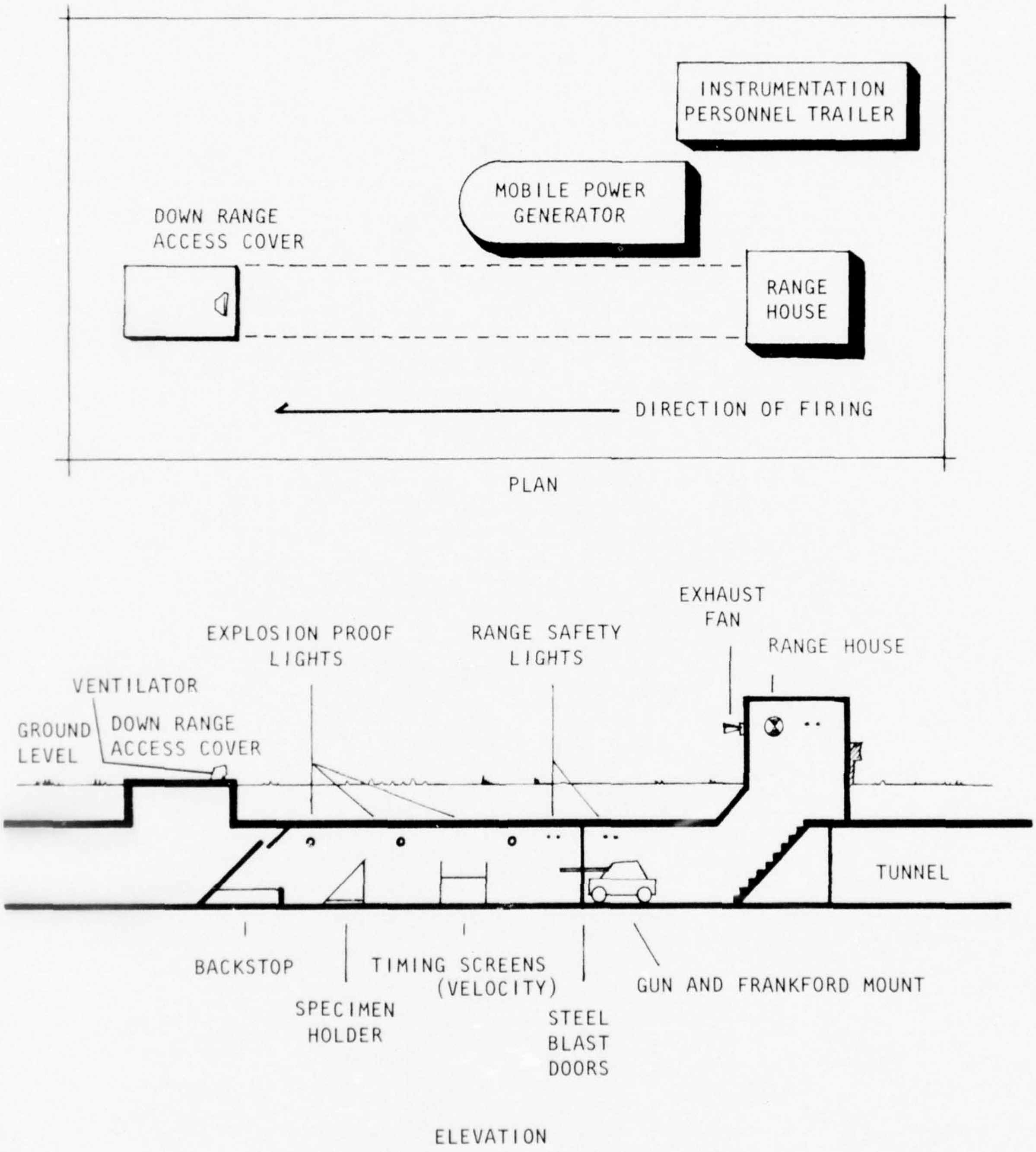

Figure V-1. Boeing Vertol Ballistic Test Facility.

ANNEX W - INTRODUCTION

OVERVIEW

The Denver Research Institute, an integral part of the University of Denver, is engaged in sponsored research in science, engineering, applied economics, and the humanities for government and industry at the international, national, and local level. Established in 1947 to broaden the research activities of the University, the Institute has conducted more than 2700 research projects totaling approximately $95 million. Present operations are at an annual volume of $6 million performed by approximately 380 scientists, engineers and supporting personnel. The Institute's laboratories, office space and conference rooms occupy 108,000 ft^2. A facility clearance of top secret has been issued by DCASR, St. Louis. Three off-campus field sites are operated for special experiments in electromagnetic propagation, ordnance and high-energy metal working studies.

The Institute consists of 10 operating divisions, one of which, the Laboratories for Applied Mechanics, operates ballistic test facilities suitable for survivability/vulnerability testing. Much of the research conducted within the Laboratories for Applied Mechanics is related to dynamic and transient physical and chemical phenomena. This emphasis is reflected in the variety of supporting facilities. Major installations include the Terminal Ballistics Laboratories, the Blast Research Range, the Explosives and Pyrotechnics Laboratory, the Air Pollution Laboratory, the Engine Testing Laboratory, the Experimental Stress Analysis Laboratory, the Instrumentation Laboratory and the Explosive Safety Laboratory. Active research areas of the Division include terminal ballistics and impact phenomena, structural mechanics, mechanics of materials, high energy reactions, blast effects, mathematical models, computer programs, measurements and instrumentation.

The Institute holds two facilities contracts (Army Contract No. DA-23-072-ORD-527(X) and Air Force Contract No. F04701-75-C-0283) which make available a variety of government-owned research equipment.

The point of contact for this facility is Mr. Chester R. Hoggatt, Division Head, Laboratories for Applied Mechanics, telephone 303-753-2616.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

Survivability/vulnerability testing can be performed on all fixed and rotary wing aircraft systems and subsystems, including complete aircraft. Full-size aircraft and/or systems and components can be suspended at the Aircraft Arena and subjected to blasts from up to 200 pounds of explosive.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Two large facilities are available for aircraft (or system) survivability/vulnerability type testing. An indoor range, located at the Denver Federal Center, can accommodate tests of inert projectiles up to 30-mm. An outdoor range has several arenas which can accommodate tests of up to 200 pounds of cased explosive statically detonated. Full sized aircraft can be suspended at the outdoor facilities.

ACCESS

The Institute is located on the University of Denver campus in South Denver at University Blvd. and Evans Ave., approximately 1/4 mile from U.S. Interstate 25. Access is by road only. The Blast Research Range is located on the Lowry Bombing Range 25 miles east of Denver. The High Kinetic Energy Laboratory range is located at the Denver Federal Center in West Denver, approximately 15 miles from the Institute. Access is by road. Rail transportation is available into Denver. Access by air is to Stapleton International, Lowry Air Force Base, or Buckley Field (Colorado National Guard).

MAINTENANCE/FABRICATION CAPABILITY

Full machine shop capability exists at Institute facilities. Ammunition loading and high explosive casting facilities are also available.

LOGISTICAL SUPPORT CAPABILITY

Ammunition storage and reloading facilities are available. Logistical support for fixed and rotary-wing aircraft and systems is available from the Colorado Air National Guard at the nearby Buckley Field.

INDOOR FACILITIES

BALLISTIC TEST FACILITY - DENVER FEDERAL CENTER

Dimensions

The test facility at the Denver Federal Center is a tunnel range 200 feet long operated by the Institute under the jurisdiction of the U.S. Navy. The facilities include an ammunition loading room, photographic processing facilities, and a general utility machine shop. The tunnel size, 5 by 7 feet, limits target size. An instrumentation/observation room is located 150 feet downrange from the gun room.

Weapons/Projectiles Available

Standard Mann barrel mounts provide the means for launching .22, .30, and .50 caliber, and 20- and 30-mm projectiles at muzzle velocities ranging up to 5000 ft/sec. To obtain muzzle velocities up to 7500 ft/sec, sabots are used to launch subcaliber projectiles and preshaped fragments from standard gun barrels. A 30-mm barrel is often employed for sabot-launching large fragments. Standard fragment-simulating projectiles required for acceptance testing armors of various materials are available.

A 1-inch gun tube 15 feet long firing through a vacuum chamber can be used for launching fragments (20 grams at 10,000 ft/sec). Explosives are also used to launch fragments at high velocity, and to impulsively load materials in order to experimentally examine dynamic behavior.

Live/Inert Fire

Only inert projectiles may be fired.

Safety (and Security) Requirements

The range is secure for classified materials and equipment. Door interlocks are used on all range doors. Range safety requirements are available on request.

Power Availability

Ample electrical power is available at 110 and 220 volts. DC and hydraulic power can be made available with portable generators.

Observation

Observation ports are located in the instrument room. The gun room can be observed from the instrumentation room using mirrors.

In-Flight Ballistic Instrumentation

The instrumentation used on this range is primarily oriented toward recording terminal effects.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. Photographs can be made using both high-speed photography and flash radiography. Hycam, Locam, Milliken, Fastex, Fairchild, Eastman, and Dynafax framing cameras are available for high-speed photography at framing rates from normal cine to 44,000 frames/sec. A Beckman and Whitley 189 camera capable of framing rates up to 1.2 million frames/sec can be obtained from the Blast Facility as required. An Avco streak camera and drum camera are utilized with high-intensity electronic strobe and explosive flash units. An Edgerton Rapatronic Shutter is also available for stopping dynamic events on film. Up to six Fexitron flash x-ray channels are available; the units are rated at 100 to 600 kV. The photo instrumentation methods used include specialized techniques such as front lighting, shadow, schlieren streak, laser, and interferometry.

TIMING. Timing is accomplished by using electronic counters and velocity chronographs. Paper screens and light screens are used with the timing devices.

HARDWIRE. Pressure, temperature, strain, and acceleration can be measured and recorded on magnetic tape, oscillographs, or multibeam oscilloscopes.

OUTDOOR FACILITIES

BLAST RESEARCH RANGE

Dimensions

Detonation physics and blast phenomena are studied at this facility which consists of six sections of Lowry Bombing Range land situated 25 miles east of Denver. The facility is operated by the Institute under the jurisdiction of the U.S. Navy. Equipment is housed in mobile and semi-mobile units. Supporting buildings include an explosives casting facility, a small shop and construction facilities, office areas, and water tanks for explosive forming and studies in hydromechanics. Four arenas are of interest for aircraft survivability testing.

The Fragmentation Arena is 102 feet in diameter and 20 feet high. There are eight high-speed camera locations. This arena is used for fragmentation studies involving fragment velocity measurements, distribution patterns and fragment recovery.

The Aircraft Arena is also approximately 100 feet in diameter. There are facilities for suspending a full aircraft in various positions for testing. Multiple smaller aircraft components or systems may also be suspended at various locations relative to the static detonation of explosives or projectiles.

The Wing Support Arena is used for tests of fragment impact against wings or wing sections. The wing support structure was designed to minimize secondary damage caused by blast-support interactions.

The VADAM (Vaporific Damage) Arena is used for studies of vaporific damage to structures (aircraft or otherwise) from hypervelocity fragments or fragment simulators. The VADAM structure (built to suppress blast from the linear shaped charges used to accelerate the fragments to hypervelocities) is 37 feet long and 19 feet high.

Additional facilities are the Near Field Blast Effects Arena and a facility for detonating explosive fuel-air mixtures.

A fire control center common to the test arenas allows synchronization of multiple test equipment. Any combination of photo instrumentation can be synchronized into the fire control center to obtain required data.

Weapons/Projectiles Available

Projectiles are statically detonated at these facilities. Up to 200 pounds of cased explosive may be detonated at the Fragmentation Arena and the Aircraft Arena. Up to 5 pounds of explosive (shaped charge) are used to propel fragments at the Wing Support Arena. Up to 100 pounds linear shaped charges are used to propel fragments to hypervelocities.

Live/Inert Fire

All detonation of projectiles is done statically.

Safety (and Security) Requirements

Classified materials and equipment may be stored at the range. Range safety requirements are available on request.

Power Availability

Electrical power is available at range buildings. Electrical or hydraulic power requirements at the test arenas are met with portable generating equipment.

Observation

No live observation of tests is allowed.

Instrumentation

All instrumentation used by the Institute is portable and can be used at either their indoor or outdoor ranges. For instrumentation information, see the *Instrumentation* section of the indoor *Ballistic Test Facility - Denver Federal Center.*

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data can be stored on computer card, magnetic tape (7- or 9-track) or disk.

QUICK-LOOK CAPABILITIES

Black and white high-speed film can be processed immediately. Color processing requires from 1 to 3 days.

PROCESSING

System and Model

The Mathematical Sciences Division acts as liaison with the University of Denver's Computing Center. The Center operates a Burroughs B6700 computer (131,[illegible] six-byte words core memory).

Language

FORTRAN, BASIC, ALGOL, COBOL and PL/I may be used for both batch and time-sharing.

INPUT/OUTPUT OPTIONS

Card, disk, and magnetic tape may be used for data input. A Data Communications Processor is included with 32 ports, about half of which are assigned to teletype-speed dial-up lines with the remainder assigned to dial-up or direct-connect terminals at higher speeds. Output is to high-speed printers or teletype. The system has four tape units for 9-track 1600 character/in. phase encoded tapes and one 7-track tape unit with capability of 200, 556 and 800 characters/in. for compatibility with other systems.

REALTIME/INTERACTION

Approximately 16 teletype terminals are available for operating in the time-sharing mode.

DISTRIBUTION (TURNAROUND TIME)

Turnaround time ranges from immediate to overnight, depending upon the size of the program and the run time required.

ANNEX X - INTRODUCTION

OVERVIEW

The Falcon Research and Development Company, a subsidiary of the Whittaker Corporation, operates a ballistic test range on 50 acres of land which used to be part of the Lowry Bombing Range. The range is located 30 miles east of Denver, CO, and is extremely isolated, making it well suited for tests of large explosive charges.

Falcon's home offi: facilities are located in Denver, CO. Technical staff offices, administrative space, a computer facility, darkroom, instrumentation laboratory, machine shop, and publication fac''ty occupy approximately 12,000 ft^2 at 1225 South Huron Street. In addition, the firm operates a Baltimore office at 696 Fairmount Avenue, Baltimore, MD, which is almost wholly engaged in support to the U.S. Army Ballistic Research Laboratories. Technical staff offices are also located in Albuquerque, NM, Buffalo, NY, and Washington, DC. Falcon has engaged in survivability/vulnerability analysis and target description work for all three services and the aircraft industry. The company also has many years of experience in explosive physics, weapons effects, military analysis and operations research, and fire and combustion research.

The primary point of contact is Mr. Daniel K. Parks, telephone 303-744-1473.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The Falcon Research and Development Company test range can be used for ballistically testing all rotary-wing or fixed-wing aircraft systems.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Up to 200 pounds of high explosive (cased) and up to 100-pound shaped charges can be fired at the Falcon Test Range. Projectiles up through 23-mm HE are fired on a 50-foot vertical range. Underground tunnels are available or a revetment could be constructed for additional projectile firing capabilities.

ACCESS

The company offices are located at 1225 South Huron Street, Denver, CO. The test range is located on the old Lowry Bombing Range, 30 miles east of Denver on East Quincy Avenue near Bennet, CO. Access to the range is by road or helicopter. Access by air is to Stapleton International Airport or the Buckley Air National Guard Base.

MAINTENANCE/FABRICATION CAPABILITY

Falcon fabricates all its own munitions, including facilities for casting large explosive charges. Pressing facilities are limited to booster pellets. A very limited machine shop capability allows fabrication of small items at the range. Full machine shop capabilities are available at the Denver facility.

LOGISTICAL SUPPORT CAPABILITY

Ammunition loading and storage facilities are available. High explosive charges (including shaped) may be cast. Logistical support for fixed- and rotary-wing aircraft and aircraft systems is available from either the Colorado Air National Guard or the U.S. Air Force (tenants) at nearby Buckley Field.

INDOOR FACILITIES

Falcon has no indoor ballistic test facilities.

OUTDOOR FACILITIES

MAIN RANGE

Dimensions

The main range is a 50-acre fenced site located within an uninhabited area 5 miles in diameter. The test area is located in an old Titan 1 launch site. The facilities include sheds, ammunition storage bunkers, instrumentation trailers, and a very limited machine shop capability. There are several blast arenas, with fixed camera mounts and underground cable lanes, which can be used for statically detonating projectiles or explosive charges.

A vertical gun range 40 feet deep, 5 feet in diameter, is used for ballistically firing projectiles up through 23-mm. A 10-ton crane is on site for handling target materials. Additional gunfire ranges are planned for construction as needed (either above ground or in existing tunnels).

Weapons/Projectiles Available

Currently, a .50-caliber weapon is available. Additional weapons are available on loan on short notice. Projectiles up to and including 23-mm HE may be fired on the vertical gun range. Fragmenting munitions up to 200 pounds and larger bare charges (and fragments charges fired underground) may be tested in the blast arenas. Explosive charges up to 100 pounds in a single pour may be cast at the range. With minor modifications, charges up to 200 pounds could be cast in this facility.

Live/Inert Fire

Fragmenting munitions up to 200 pounds may be statically detonated. Live HE projectiles up to and including 23-mm may be fired on the vertical range.

Safety (and Security) Requirements

Facilities are available for storage of classified materials at the range. Range safety requirements are available on request.

Power Availability

Standard 110- and 220-volt electrical power (60-cycle, single-phase) is available at the range (30 kW). Additional requirements can be met with portable generators.

Observation

No direct observation is allowed. Tests can be observed by mirror.

In-Flight Ballistic Instrumentation

Tests and instrumentation at this facility are oriented toward terminal effects.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. Multiple Hycam and Fastex high-speed cameras with framing rates up to 9000 frames/sec (17,000 split frame) are used to record test results. Millikan cameras (400 frames/sec) and a Beckman Whitley (Cordin) Model 189 camera system (200,000 to 2.4 million frames/sec) are also available. The equipment and capabilities are available for obtaining the full range of photographic coverage simultaneously with the ultra high-speed camera.

TIMING. Paper and light screens are used with electronic timers of μsec accuracy. 1000 cycle/sec timing lights are used on the 16-mm cameras.

HARDWIRE/TELEMETRY. Piezoelectric transducers measuring strain, pressure, temperature, and similar measurements are recorded on magnetic tape (two 14-channel recorders), recording oscilloscopes, or oscillographs.

Environmental Simulation and Measurement

None.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data can be stored on magnetic tape, disk or computer card.

QUICK-LOOK CAPABILITIES

There are no quick-look capabilities; however, since film processing is done in-house, film can be developed immediately.

PROCESSING

System and Model

Computer and data processing services are provided by a General Automation SPP-16/85 Computer (40,000-core memory).

Language

FORTRAN, BASIC, and Assembly Language may be used.

Input/Output Options

Standard I/O options are available in addition to a Calcomp Plotter Model 936. Tapes are 9-track, 800 bpi, and are IBM compatible.

Realtime/Interaction

Realtime interaction is minimal.

DISTRIBUTION

Turnaround time can be immediate if desired, since the computer is operated by Falcon.

ANNEX Y - INTRODUCTION

OVERVIEW

The Firestone Coated Fabrics Company's ballistic test range was designed and is used for testing self-sealing fuel cells and bladders and inerting systems. It is located at 2525 Firestone Blvd. in Southgate, CA, a suburb of Los Angeles.

The primary point of contact concerning testing at this facility is Mr. V. J. Matteson, Manager, Test Facility, telephone 213-583-0123.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

This facility is dedicated to the testing of self-sealing aircraft fuel system components.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

There is one outdoor range at this facility. It is well designed, equipped, and instrumented for its intended use.

ACCESS

The Firestone facility is easily accessible by all means of transporation. It is 2 miles from the intersection of the Long Beach Freeway (California Route 7) and Firestone Blvd. A spur of the Southern Pacific Railroad extends onto the Firestone plant. Los Angeles International Airport is 10 miles west of the facility. The Los Angeles Harbor is 15 miles south of the facility.

MAINTENANCE/FABRICATION CAPABILITY

Complete maintenance and fabrication support is available from the Firestone manufacturing plant which is colocated with the facility.

LOGISTICS SUPPORT CAPABILITY

An ample supply of all calibers of ammunition is stored at the facility. Other logistical support is available from the colocated manufacturing plant.

INDOOR FACILITIES

No indoor test facility is available at this site.

OUTDOOR FACILITIES

DIMENSIONS

The weapon mount is in a small building which opens onto an open area which terminates in a backstop and fuel containment area 75 feet away.

WEAPONS/PROJECTILES AVAILABLE

Operational weapons of .30, .50, and .60 caliber and 14.5- and 20-mm are available on the range. Standard operational rounds of ball, AP and API ammunition can be used in all tests.

ENVIRONMENT

All tests are conducted under low temperature -75°F or ambient conditions.

LIVE/INERT FIRE

Only ball or API rounds may be fired on this range.

SAFETY (AND SECURITY) REQUIREMENTS

Classified materials can be tested in this facility. Fuel quantities are limited to 400 gallons for any test. Firefighting equipment must be present during all testing.

POWER AVAILABILITY

Commercial electrical power of 110 and 220 VAC is available on the range.

OBSERVATION/COMMUNICATION

Direct visual observation is permitted from the firing point. No communication other than voice is provided on the range.

IN-FLIGHT BALLISTIC INSTRUMENTATION

Laser/Photography

A variety of high-speed motion picture and still cameras are available from a central instrumentation pool at the Firestone plant.

Timing

Paperbreak velocity screens are used in conjunction with oscillographs to measure projectile velocities.

Hardwire/Telemetry

All instrumentation is connected by hardwire circuits.

TERMINAL BALLISTIC INSTRUMENTATION

Laser/Photography

A variety of high-speed motion picture and still cameras are available for recording impact phenomena.

Timing

Various sensors for measuring pressure, temperature, or other forces are used in conjunction with oscillographs for recording terminal effects.

Hardwire/Telemetry

All instrumentation is connected by hardwire circuits.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The data collected at this facility are in the form of photographs, oscillograph traces, and high-speed film. These are normally reduced manually and stored in hard copy.

QUICK-LOOK CAPABILITIES

Data are usually available for quick-look analysis within a few hours after the completion of a test.

PROCESSING

Data analysis is normally accomplished through manual means. The relatively small volume of test data have not made computer processing desirable or economically feasible.

ANNEX Z - INTRODUCTION

OVERVIEW

The GE/ASD (General Electric Company, Armament Systems Department), operates under contract DAAA09-74-C-2065 a weapons testing range in Underhill, VT, approximately 20 miles east of its engineering and manufacturing facilities in Burlington, VT. Current contracts authorize (through approved safety plans) the firing of 5.56-, 20-, 7.62-, and 30-mm weapons from fixed locations, and limited firings from helicopters on the General Electric managed portion of the range. Air space is restricted and under the joint control of the Vermont National Guard, General Electric Company, and the Burlington Airport Office of the FAA.

Any proposed usage of the area of the Underhill Range managed by General Electric for the U.S. Army Armament Command would require specific contractual coverage by the contracting officer.

GE/ASD is engaged in designing, developing and manufacturing many advanced armament systems utilizing the 20-mm M61 Vulcan gun, its M-197 derivative, the 7.62-mm M134 minigun and the 30-mm GAU-8 Avenger gun. Armament systems designed and built by GE/ASD currently arm F-104, F-105, F-106, F-4E, F-111, A-7, F-14, F-15, F-16, F-18, OV-10 (HOGS), A-37, A-4, and A-10 aircraft; AH-1G, AH-1J, HH-53, UH-1F, UH-1N, OH-6, OH-58, CH-53, SH-3, and UH-1B helicopters; C-47, C-119, and C-130 gunships; M-163 and M-167 Vulcan Air Defense Systems. Advanced programs include single barrel weapons from 7.62- to 30-mm, lightweight guns, liquid propellant weapons, high performance mounts and armament stations, new air defense system, ammunition development, barrel material studies, and plastic components.

GE/ASD's production facilities in Burlington have over 500,000 ft^2 under roof at three facilities. These are supported by the Underhill Firing Range, approximately 2000 acres which presents ideal conditions for testing explosive ordnance, rockets, guns, feed systems, and a variety of armament. GE/ASD has well-equipped facilities capable of supporting armament and materials evaluation, development and research programs. The primary points of contact for this facility are:

1. Total Underhill Range (GE and National Guard managed portions):

   LCDR Everett P. Diener
   Dir. I&S
   U.S. Army Armament Command
   Rock Island, IL 51201
   AMSAR-IS

2. General Electric Managed Portion:

a. Technical

Mr. B. B. Follett, Manager
Firing Range
General Electric Co.
Lakeside Avenue
Burlington, VT 05401
802-658-1500, ext. 6281

or

Mr. J. M. Trumper, Manager
Advanced Armament Systems Engineering
General Electric Co.
Lakeside Avenue
Burlington, VT 05401
802-658-1500, ext. 6428

b. Contractural

Mr. H.E. Wright, Manager
Operational Planning
General Electric Co.
Lakeside Avenue
Burlington, VT 05401
802-658-1500, ext. 6496

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The Underhill Firing Range performs both production and developmental tests on armament systems including guns up to 30-mm. Tests can be conducted from eight firing lanes oriented toward gun production testing, or from four ranges for HE effects tests, ballistics testing, or from aircraft.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The Underhill Firing Range consists of a production testing range with eight firing lanes and five auxiliary firing ranges. One is used for firing HE rounds and one has a bullet catcher. The primary range can be used to conduct eight different weapon systems tests sequentially with automatic computer controlled data collection.

ACCESS

Access to the range is via secondary state roads. The production facilities in Burlington have access to both rail and air transporation.

MAINTENANCE/FABRICATION CAPABILITY

The GE/ASD production plants have complete machine shops for fabricating test specimens and fixtures in addition to production facilities for fabricating complete armament systems. A less extensive machine shop capability exists at the range itself. Maintenance for all aircraft systems could be made available through either the Burlington Air National Guard or from the nearby Plattsburg Air Force Base.

LOGISTICAL SUPPORT CAPABILITY

Extensive shop and laboratory support facilities are available at the Burlington production facilities. Ammunition and weapon storage facilities at the range are also extensive (including Class A and C explosives). Ordnance loading facilities are available at the range.

INDOOR FACILITIES

One indoor range is located at the Lakeside Avenue plant in Burlington but it is not oriented toward survivability/vulnerability testing. This range, 20 feet long with a 3-, by 3-foot impact area, could be modified for small caliber impact tests if necessary.

OUTDOOR FACILITIES

MAIN RANGE

Dimensions

The Main Range consists of eight enclosed fixed stations which can be used sequentially. Each station has a gun mount capable of mounting single or multibarrel weapon systems for testing gun, turret, feed and sighting systems, and safing and arming devices. Each station is approximately 15 by 15 by 15 feet. A target stand is located 1000 inches from the stations. Projectiles are stopped by a dirt hill (80 feet high) approximately 200 yards from the firing station.

Weapons/Projectiles Available

Guns are available for firing up to 40-mm projectiles at this range. Only inert ammunition is fired at this location.

Live/Inert Fire

Inert projectiles only may be fired from these firing stations.

Safety (and Security) Requirements

Safety and security requirements are available from the range safety officer.

Power Availability

Electrical power at either 60 or 400 cycles is available at various voltages up to 480 volts. DC voltages commonly used on aircraft and ground vehicles are also available. Hydraulic power up to 5000 psi (at 60 gal/min flow) is also available at each lane.

Observation

Tests can be observed directly through ports at most stations.

In-Flight Ballistic Instrumentation

PHOTOGRAPHY. The photographic equipment shown in Table Z-1 is available at the Underhill range in addition to various cameras for still photographs.

TIMING. Timing is down with ballistic light screens or paperbreak. A typical arrangement of four screens can be used to provide horizontal and vertical round positions relative to boresight and round velocity automatically via the RDAS (Range Data Acquisition System) for each round during burst firing. IRIG-B timing is used for system timing.

HARDWIRE. Pressure, temperature, strain or torque can be recorded automatically through the RDAS computer system on 11 analog channels. Additionally, separate (10 each) 18- and 52-channel oscillographs can be used.

OTHER. The RDAS provides rapid data processing of test results from weapon system instrumentation. Lane instrumentation (from each lane) is directly connected to RDAS. This system provides the capability for extensive data processing towards immediate printed output of usable results. The following equipment provides this capability:

1. 140 DEC Processor (64,000 core)
2. IMS with Calelus Disk Drive (one fixed, one removable)
3. Realtime Oscillograph (24-channel)
4. DEC GT40 Graphics Terminal (28,000 core)
5. Teletype to each lane
6. Analog Tape drives
7. Printec 100-line printer.

This equipment provides 11 analog channels (with planned expansion to 24) and 16-event channels.

Terminal Ballistic Instrumentation

Instrumentation is available for in-flight measurement and terminal effects also.

Environmental Simulation and Measurement

Weapons and targets can be temperature conditioned (-65° to +265°F).

VEHICLE AND HELICOPTER RANGE

Dimensions

Vehicle firing is done from a 50- by 50-foot building. Target areas are available at ranges up to 1400 meters. Helicopter ground firing can be done from the 50- by 50-foot pad adjacent to the vehicle test building.

Weapons/Projectiles Available

Inert projectiles up to 40-mm can be ground fired at target distances of up to 1400 meters. Helicopters can air-fire inert projectiles at targets up to 12,000 feet.

Live/Inert Fire

Projectiles fired must be inert.

Safety (and Security) Requirements

Safety and security requirements are available from the Range Safety Officer.

Power Availability

Electrical power (60-cycle, 75 kVA) is available at this site. Hydraulic power can be provided by two portable units (to 3000 psi) at 54 gal/min and to 5000 psi at 30 gal/min.

Observation

Gunfire tests can be observed from the firing building.

Instrumentation

All instrumentation at the Underhill Firing Range is portable except the RDAS recording and processing system. Direct print oscillograph recorders are used for data acquisition.

MUNITIONS TEST AREA

Dimensions

Firing at this range is done from two 10- by 15-foot armored firing rooms (one lead lined for use of x-ray equipment) and from a 20- by 42-foot concrete pad with a movable roof. Weapons are fired into reinforced concrete bunker 79.55 meters downrange. The bunker is 12 by 12 feet, 33 feet deep. Targets such as trucks, helicopters, or large aircraft sections can be used.

Weapons/Projectiles Available

Projectiles up to 40-mm HE or shaped charge may be fired.

Live/Inert Fire

See *Weapons/Projectiles Available.*

Safety (and Security) Requirements

Safety and security requirements are available from the Range Safety Officer.

Power Availability

Electrical power (60-cycle) is available at this range. Other electrical or hydraulic power requirements can be met with portable units.

Observation

Tests cannot be directly observed.

Instrumentation

All instrumentation at the Underhill Firing Range is portable except the RDAS recording and system. See *Main Range Instrumentation* documentation for specifics.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

See the RDAS documentation in the *Main Range Instrumentation* section.

QUICK-LOOK CAPABILITIES

See the RDAS documentation in the *Main Range Instrumentation* section. B&W film can be processed immediately. Color processing requires approximately a week.

PROCESSING

Data processing can be accomplished on the RDAS at the range. The following additional processing systems are available at the Burlington facilities.

System and Model

The following systems are available for use:

1. GE Mark III Time-Sharing
2. Honeywell 6000 series general purpose digital computer located in Utica, NY, through a time-sharing or remote batch mode.
3. In-house Honeywell G 400.
4. EAI 680 Analog Computer.
5. Interactive Graphics Terminals.

Language

Most common computer languages are available on one or more of the above systems.

Input/Output Options

Standard I/O options are available. A Calcomp drum plotter is available on the Honeywell G 400. An X-Y plotter, CRT, 8-channel brush recorder and analog tape drives are available on the EAI 680. Approximately 10 terminals are available for the time-sharing systems.

Realtime Interaction

Time-sharing terminals are available.

DISTRIBUTION (TURNAROUND TIME)

Turnaround time is usually excellent (depending upon the length of job).

Table Z-1. Available Photographic Equipment.

Number	Type
2	16-mm Arriflex movie cameras
3	16-mm Fastex high speed movie cameras (100 feet) 8000 frames/sec
1	16-mm Hycam high speed movie camera (400 feet) 22,000 frames/sec
1	16-mm High speed movie camera (100 feet) 8000 frames/sec
1	16-mm Locam movie camera 5 to 500 frames/sec
2	Micro Flash equipment set
1	Video Logic (video tape) equipment
2	600 kV pulsed x-ray equipment
1	300 kV pulsed x-ray equipment
4	180 kV pulsed x-ray equipment

ANNEX AA - INTRODUCTION

OVERVIEW

The Wingfoot Lake Fuel Cell Test Facility is operated by the Engineered Fabrics Division of the Goodyear Aerospace Corporation. The facility is located 8 miles east of Akron, OH, and does developmental testing, qualification and production testing of rubberized fabric products from other Goodyear plants. In addition to gunfire tests, the following tests are performed at this facility:

1. Slosh and Vibration (Hot and Cold)
2. Temperature
3. Fitting
4. Pressure
5. Puncture and Impact Tear
6. Drop (to 85 feet)

The test facilities are supported by the developmental and production facilities of Goodyear Aerospace Corporation. Primary point of contact is Mr. James E. Wells, Product Manager, Engineered Fabrics Division, telephone 216-794-7302.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The primary function of the test facility is to perform developmental and production tests of rubberized fabric products. Self-sealing and crash resistant fuel cells and fuel lines constitute a significant portion of these products. Full size fuels can be tested as well as material panels up to 2 by 2 feet in test cells. Cells installed in aircraft sections can also be tested.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

One open 75-foot gunfire range is available to shoot up to 23-mm HEI projectiles. Excellent firefighting capability will allow test firing at full fuel cells. The Goodyear Aerospace Corporation is currently under a military contract which would facilitate arrangements for conducting gunfire tests for other outside users.

ACCESS

All modes of transportation are available in the area. Final delivery of materials to the test site is by truck.

MAINTENANCE/FABRICATION CAPABILITY

Limited machine shop facilities are available at the test site. Full maintenance and fabrication facilities are provided by the Goodyear Aerospace production facilities 8 miles away.

LOGISTICAL SUPPORT CAPABILITY

The test facility can provide storage for up to Class IV ammunition. Reloading facilities are available for up to 20-mm projectiles.

INDOOR FACILITIES

No indoor gunfire facilities are available.

OUTDOOR FACILITIES

GUNFIRE RANGE

Dimensions

Gunfire tests are conducted from a 20- by 20-foot building across an open 75-foot range. The target area is a 15- by 20-foot concrete pad backed by a sand hill. Target handling at the pad is facilitated by one 5-ton and two 2-ton cranes. Targets up to 15 feet high can be accommodated. A drain (into a recovery tank) is located in the center of the pad to reduce the fire hazard during fuel tests. (Fuel storage for 32,000 gallons of fuel is on site.)

Weapons/Projectiles Available

The following caliber smooth-bore barrels are available: .234, .30, .40, .50, and .60. Rifled barrels are available for 7.62-, 12.7-, 14.5-, 20-, and 23-mm. Projectiles up to 20-mm can be reloaded on site.

Live/Inert Fire

Live fire of the above calibers is permissible.

Safety (and Security) Requirements

Range safety requirements are available on request. There is no approved storage for classified materials at the test site, but facilities are available at Goodyear Akron plant (enclosed ground floor, drive in—approximately 20,000 ft^2).

Power Availability

Electrical power is available at 110 and 440 VAC and 14 to 28 VDC.

Observation

No direct observation of tests is allowed using HE projectiles.

In-Flight Ballistic Instrumentation

In-flight instrumentation is usually limited to projectile velocity measurement using paperbreak and an Autron timer.

Terminal Ballistic Instrumentation

PHOTOGRAPHIC. The following cameras are available:

Camera	Speed, frames/sec	Capacity, ft
Photosonic	0-1000	400
Hycam	0-11,000	400
Fastex (2)	0-8000	
Standard Motion Picture		

TIMING. Timing is accomplished using paperbreak and chronograph.

HARDWIRE/TELEMETRY. Pressure, temperature and strain measurements may be recorded using a 14-track Sangamo tape recorder or an 18-channel Bell and Howell Recording Oscillograph.

Environmental Simulation and Measurement

Test cells and their contents may be temperature-conditioned prior to test firing.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data can be stored on disk or tape.

QUICK-LOOK CAPABILITIES

Recording oscillograph records are available immediately. B&W film is available within 1 to 2 days. Color film processing requires approximately a week.

PROCESSING

System and Model

IBM 370 and 1130 models and a Xerox Sigma 9 computer systems are available in addition to analog computing facilities.

Language

FORTRAN and assembler languages are usually used. The IBM 370 also supports COBOL and PL/1.

Input/Output Options

The usual I/O options are available. In addition, the IBM 1130 has a CRT display and a Calcomp Plotter and the Sigma 9 has several remote terminals.

DISTRIBUTION (TURNAROUND TIME)

Turnaround time is usually 5 to 10 minutes (seldom more than 2 to 3 hours).

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ANNEX BB - INTRODUCTION

OVERVIEW

The Arizona Division of Goodyear Aerospace Corporation is located in Litchfield Park, AZ. The Division plant facilities occupy more than 100 acres adjacent to the Phoenix-Litchfield Municipal Airport, 18 miles west of Phoenix. The plant includes approximately 1,142,095 ft^2 of floor space, of which 810,013 ft^2 are available for manufacturing activities. Approximately 78,000 ft^2 of the manufacturing area are utilized for the manufacture of plastic components and assemblies. The ballistic test facility is used primarily to support the plastics division.

Goodyear Aerospace has pioneered in the development and production of lightweight armor materials, both opaque and transparent, which are applicable to combat aircraft. The primary contact for this facility is Mr. John Harman, telephone 602-932-3232, ext. 452.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The ballistic test facility at the Goodyear Aerospace, Litchpark Park plant is used primarily for testing transparent armor materials and for determining the spall characteristics of other plastic materials.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The ballistic test facility is shown in Figure BB-1. This underground facility is extensively used for testing the ballistic protection properties of various composites and candidate materials under development. It is within walking distance of all other Arizona Division plant facilities.

ACCESS

The facility is located just off U.S. 80 on Litchfield Road. It is adjacent to the Phoenix-Litchfield Municipal Airport which has runways capable of handling the largest cargo aircraft. It is approximately 18 miles west of the Phoenix Sky Harbor International Airport which is served by scheduled airlines. A spur of the Southern Pacific Railroad extends to the plant area.

MAINTENANCE/FABRICATION CAPABILITY

The Arizona Division Plant has complete machine shops for fabricating test fixtures in addition to production facilities capable of fabricating test specimens.

LOGISTIC SUPPORT CAPABILITY

Extensive shop, storage, and laboratory support are available in the Arizona Division facilities.

Precision cartridge loading facilities for standard rounds up to and including .55 caliber are available. Storage is available for complete rounds and for propellant.

INDOOR FACILITIES

BALLISTIC TEST FACILITY

Dimensions

The Ballistic Test Facility consists of a buried steel culvert which is 12 feet in diameter and 35 feet long. Two rooms of reinforced concrete construction are attached to one end of the range. One room is used for storage of weapons and supplies and the other is used as a cartridge loading facility. Figure BB-1 shows the configuration of the indoor facility while Figures BB-2, BB-3, and BB-4 show views of the facility.

A steel bulkhead and door separate the storage room from the firing area. A wooden bulkhead backed by earth fill provides a backstop for bullets and fragments.

Normal distance between the weapon and test specimen is 15 feet. Distances up to 30 feet may be used.

Weapons/Projectiles Available

Rifled weapons at .22, .223, .30, .308, .38, .44, .45, .50 and .55 caliber and 5-, 5.56-, 7.65-, and 9-mm are available. Ball and AP ammunition are available for various weapons. Precision loading equipment permits desired velocities to be achieved.

Environment

No artificial environments can be induced on the range. Test specimens can be preconditioned if very warm or very cold temperatures are necessary for the test.

Live/Inert Fire

Inert projectiles up to .55 caliber can be fired on this range.

Safety (and Security) Requirements

Since this is an underground facility, the safety of personnel not involved in the test is assured. A warning light is used to alert personnel in the area that firing is in progress.

All firing is conducted by a lanyard with the test personnel protected by either the steel door at the entrance to the range or by a transparent armor shield behind the weapon.

The wooden backstop prevents ricochetes within the facility and the earth fill behind the backstop is sufficient to contain any projectile which can be fired in the facility.

The Arizona Division Plant is a cleared facility and adequate security arrangements exist for the conducting of tests at the Secret level.

Power Availability

Commercial electrical power of 110 and 220 VAC is available in the facility. Special power requirements can be met by portable generators.

Observation/Communication

No observation of tests is normally required nor permitted. In those cases when observation is considered necessary, a portable, transparent armor shield is emplaced behind the weapon and firing is conducted from behind this shield.

Due to the limited size of the facility, no communication system is required.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Cameras available to the Ballistic Test Facility include:

1. Hycam Model 4000 - 11,000 frames/sec
2. Eastman - 3000 frames/sec
3. Nova - 6000-11,000 frames/sec

These cameras are not normally used for recording in-flight ballistics data, but rather for recording data on test sample behavior at impact.

TIMING. A μsec counter, triggered by photoelectric screens is used to measure projectile velocities.

TELEMETRY. Data are transmitted to the counter by hardwire connections.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. The high-speed cameras listed above are primarily used to record terminal ballistic data.

TIMING. No terminal ballistic timing data are collected.

TELEMETRY. None.

Environmental Simulation and Measurement

None.

Planned Expansion/Modification

There are no present plans to expand to modify this facility.

OUTDOOR FACILITY

Outdoor ballistic testing of large components is accomplished adjacent to the indoor range or on an abandoned airfield in the desert west of the plant. Figure BB-5 shows a typical outdoor test layout.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data are stored in hard copy and motion picture film. Data are filed by test and are manually retrieved.

QUICK-LOOK CAPABILITIES

Velocity data are available immediately after a test. Photographic data are routinely available within 5 working days.

PROCESSING

All data are manually processed.

DISTRIBUTION

Turnaround time for velocity data are near realtime. Photographic processing is routinely completed within 5 working days.

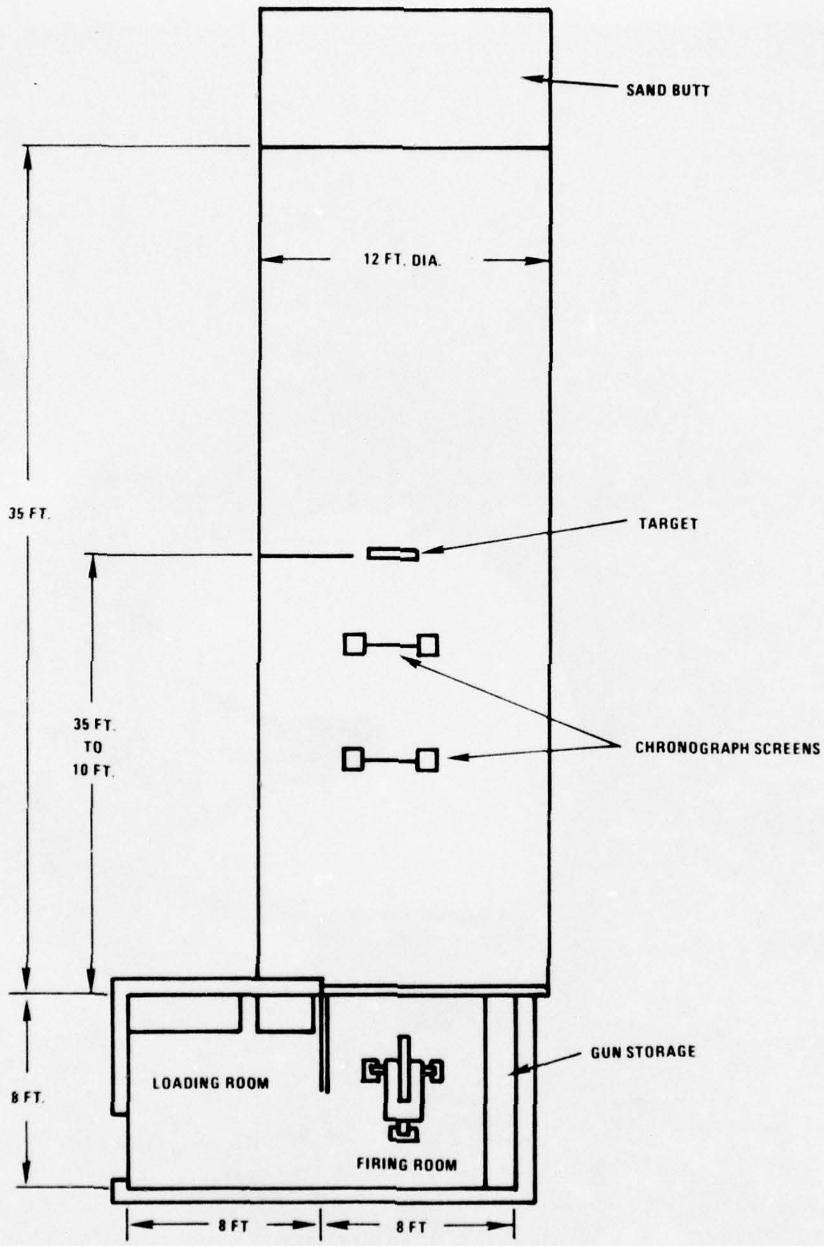


Figure BB-1. Indoor Test Facility.

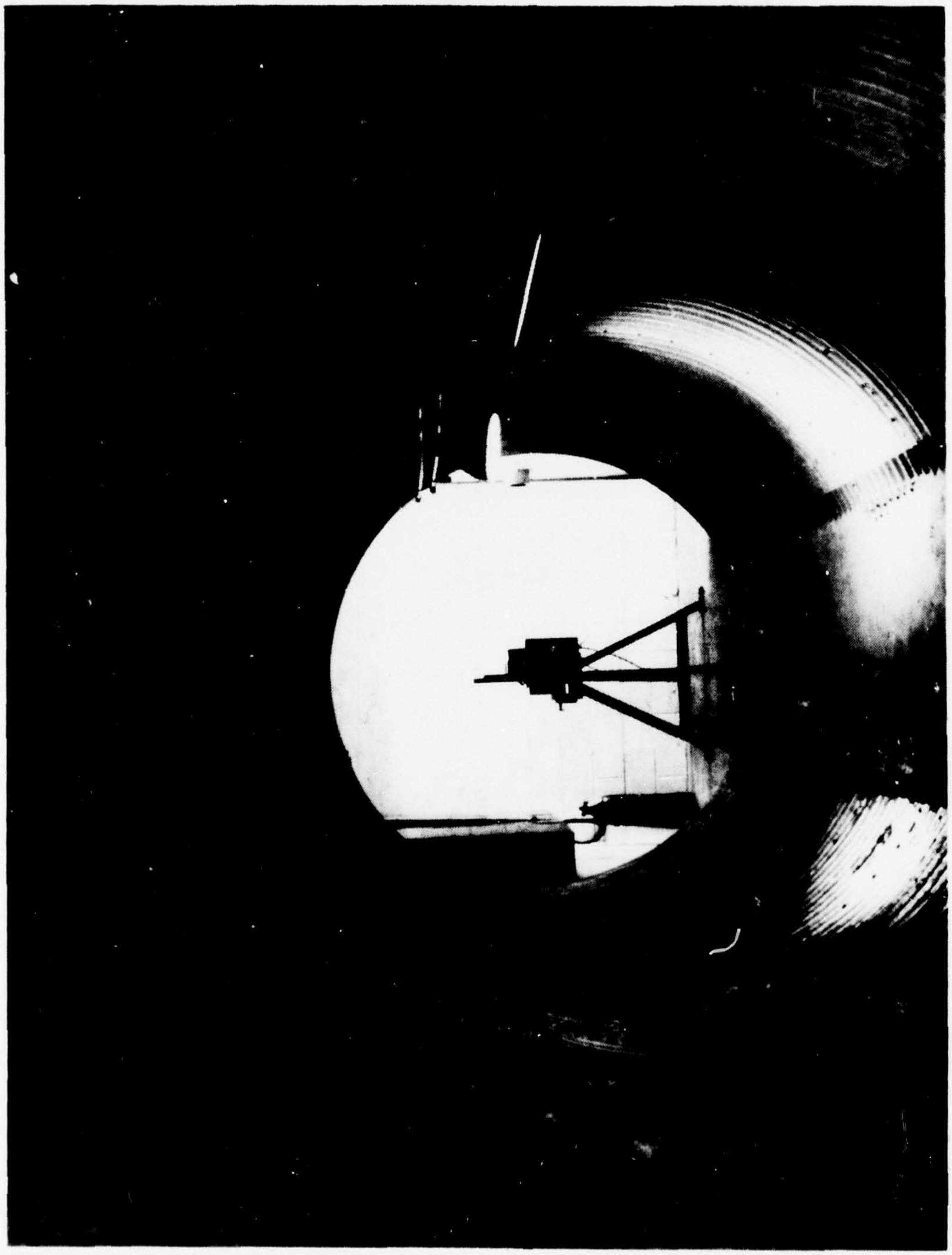


Figure BB-2. Test Facility as Viewed from Target Area.

Figure BB-3. Test Facility as Viewed from Launcher Area.

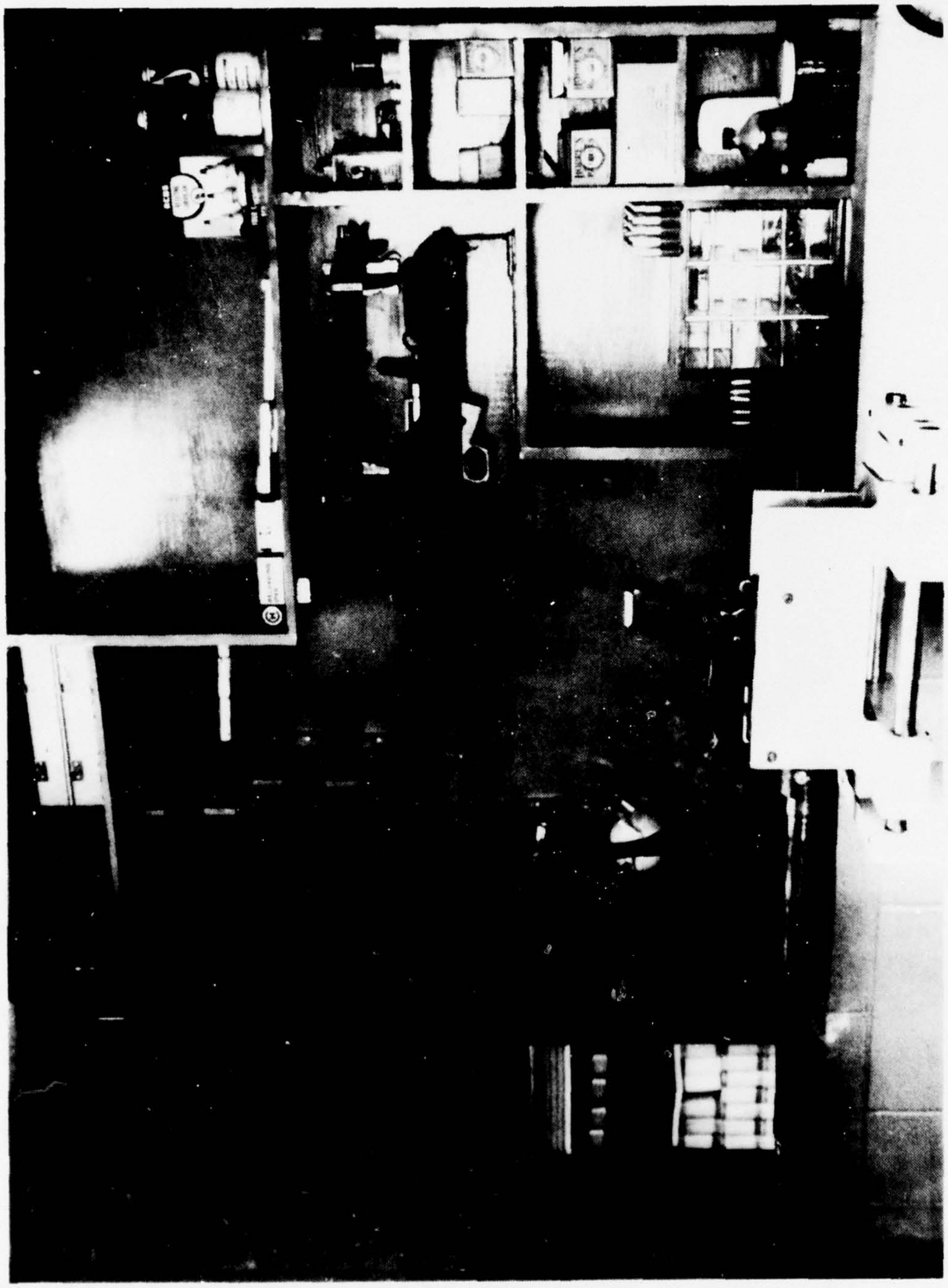


Figure BB-4. Weapons Storage Area.

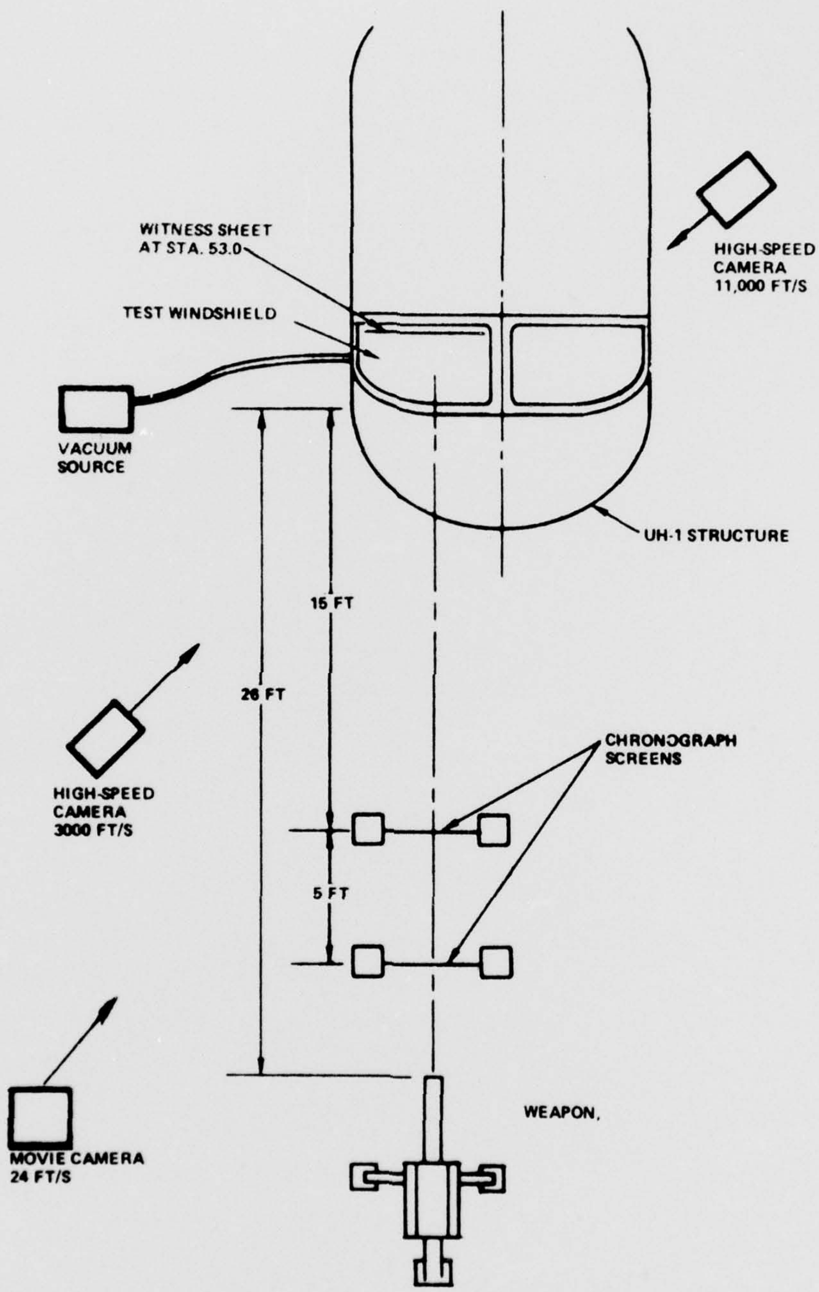


Figure BB-5. Typical Outdooor Testing Litchfield Park Facility.

ANNEX CC - INTRODUCTION

OVERVIEW

The Hughes Helicopter Ordnance Engineering Test Facility is located in Culver City, CA at the intersection of Centinela Avenue and Teal Street. This facility provides ordnance test support for corporate development programs and is not usually available to outside users.

While this facility is not oriented toward survivability/vulnerability testing, it has the facilities required for this type testing and could conduct such testing if required to do so.

The primary point of contact for matters concerning ballistic testing is Mr. Robert W. Forker, telephone 213-390-4451.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTING

The facility has been used for testing structural subsystems of helicopters, high performance and medium performance aircraft.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The Hughes test complex includes six indoor 500-inch ranges, one indoor 1000-inch range and two indoor-outdoor 1000-inch ranges. The controls, instrumentation and data recording systems are identical for all ranges.

In addition, a completely self-contained mobile instrumentation van is maintained for testing at remote sites such as Fort Irwin or Camp Pendleton.

ACCESS

Excellent access to the Hughes facility is provided by its location in the Los Angeles Metropolitan Area. The plant is 3 miles north of the Los Angeles International Airport via California Route 1. The company airport, immediately adjacent to the facility has an 8800-foot runway which can handle cargo aircraft up to the C-141 class. A spur of the Southern Pacific railway extends into the plant. Interstate 405 is accessible within 1 mile of the plant. The Los Angeles Harbor is approximately 25 miles south of the plant via Interstate 405 and California Route 11.

MAINTENANCE/FABRICATION CAPABILITY

The extensive maintenance and machine shop support available is that which is found in most major manufacturing activities.

LOGISTICS SUPPORT CAPABILITY

Complete logistics support of all kinds is available to the test facility.

INDOOR FACILITIES

DIMENSIONS

Each 500-inch range has a 20-ft^2 gun room from which weapons are fired. The ranges have a 6-foot-diameter tunnel leading from the gun room to the backstop. The 1000-inch indoor range is 20 feet wide, 12 feet high and 1000 inches long. The 1000-inch indoor-outdoor ranges have a 20-ft^2 gun room which opens into a walled area 1000 inches long. Each range abuts on a backstop consisting of a sand filled concrete pentagon which is revetted by earth fill outside.

WEAPONS/PROJECTILES AVAILABLE

Barrels ranging in size from .17 caliber to 40-mm are available. Most firing is conducted with standard preloaded ammunition.

ENVIRONMENT

All tests are conducted against targets which are under ambient conditions. Weapons and ammunition may be preconditioned to temperatures of -65° to 160°F.

LIVE/INERT FIRE

Armor piercing and armor piercing incendiary ammunition can be fired on these ranges.

SAFETY (AND SECURITY) REQUIREMENTS

The Hughes facility holds a Secret clearance and can accommodate tests involving material to that level of classification.

The test facility is surrounded by security fencing and access is limited by locked gates.

Safety procedures are enforced by a gun captain for each range. Electrical firing controls are normally used for all tests. Warning lights preclude firing when the gun room doors are not secured. A warning horn is sounded 4 seconds before firing.

POWER AVAILABILITY

Commercial electric power of 110, 220, and 440 VAC and 400 cycles is available in the test facility. Hydraulic power up to 3000 psi is provided and compressed air of up to 4000 psi is available.

OBSERVATION/COMMUNICATION

An intercommunication system is installed on all ranges.

Direct visual observation of tests is provided by ballistic tolerant glass panels at the control station and at an observers station.

IN-FLIGHT BALLISTIC INSTRUMENTATION

Laser/Photography

The test facility has a variety of photographic equipment including:

1. Three Hycam high-speed cameras with frame rates of up to 4000 frames/sec. One of these is a streak synchronized ballistic model.

2. One Fastex high-speed camera with frame rates of up to 2000 frames/sec.

3. Several 16-mm cameras with frame rates of up to 100 frames/sec.

4. Several 4- by 5-inch still cameras.

Equipment is also available for making Schlerin photographs of shock waves.

Additional photographic support is available from other departments of the company.

Black and white film is processed on site while color film is processed by an outside commercial processor.

Timing

Velocity measurements are made by an electronic chronometer which may be triggered by paperbreak velocity screens, induction coils or light breaks systems.

Spin rate measurements are made by magnetising bullets which are fired through a coil.

Hardwire/Telemetry

All range data are transmitted to a conical recording facility via hardwire circuits. The data center is equipped with high-speed magnetic tape recorders, 10- and 20-channel oscillographs, multichannel oscilloscopes with memory and automatic rate of fire recorder. Over 100 channels of data may be simultaneously transmitted from sensors which measure pressure, blast, strain, position and linear velocity displacement.

TERMINAL BALLISTIC INSTRUMENTATION

The instrumentation described above can also be used to provide data concerning terminal effects.

OUTDOOR FACILITIES

No permanent outdoor test facilities are maintained by Hughes. As noted previously, a self-contained instrumentation van is maintained for use at remote test sites. This van includes control and recording instrumentation, a photographic processing facility work shop and office space.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The data collected in this facility are in the form of photographs, oscilloscope traces, and analog recordings on magnetic tape. These are normally stored in hard copy. Facilities are available for transferring these data to magnetic tape for computer storage and retrieval if this is desirable.

QUICK-LOOK CAPABILITIES

Since most data are produced in hard copy in near realtime, quick-look analysis is possible within a very short time after a test is completed.

PROCESSING

Data processing is normally done manually. If the quantity of test data can be more efficiently handled by computer, one of several on-site computers or terminals can be used.

DISTRIBUTION

Turnaround for all data is very rapid. As noted earlier, most electronically recorded data are available in near realtime and black and white film is processed in-house with 1 hour or less being required.

ANNEX DD - INTRODUCTION

OVERVIEW

The New Mexico Institute of Mining and Technology is a unique state-supported scientific institution combining basic research, applied research, and education. The Institute, located in Socorro, NM, is organized in three divisions: College, Research and Development, and the State Bureau of Mines and Mineral Resources.

Ballistic testing is conducted by the TERA (Terminal Effects, Research and Analysis) Group with the Research and Development Division. The TERA Group has been conducting ballistic and explosive testing for various government agencies for over 30 years. In addition to the gun test facilities described in this annex, TERA maintains and operates extensive facilities and instrumentation for conducting large-scale explosive tests. They have developed unique fragment recovery techniques which enable complete analysis of the fragment dispersal patterns of bombs or warheads. The full range of testing and analysis services offered by this facility admirably suit it for many types of S/V testing.

The primary point of contact concerning testing in the TERA facility is Mr. M. L. Kempton, TERA Project Supervisor, telephone 505-835-5630.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The TERA test facilities are capable of testing all types of aircraft under static or dynamic conditions. Target vehicles on hand include a variety of fixed- and rotary-wing aircraft.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The TERA test facilities are grouped in two complexes, the Blue Canyon Field Laboratory and the West Valley Test Facility. An overview is shown in Figure DD-1. In each of these outdoor complexes facilities are available for a wide variety of survivability/vulnerability testing. The test facilities are supported by an extensive logistics, maintenance and fabrication capability which is organic to the TERA Group. Data collection, reduction and analysis is facilitated by the dedication of extensive instrumentation to the test programs and by the immediate availability of the Institute's computer complex.

ACCESS

The TERA test facilities are easily reached by Interstate 25 from either Albuquerque or El Paso. The Atchison, Topeka, and Santa Fe Rail Road provides rail service to Socorro with its freight station only 1-1/2 miles from the TERA headquarters. Commercial air service is through the Albuquerque International Airport. The Socorro Municipal Airport is capable of handling medium cargo aircraft.

MAINTENANCE/FABRICATION CAPABILITY

The NMT Research and Development Division maintains a complete machine shop adjacent to the TERA offices. Its equipment includes: jig borers, radial arm drill, large and small engine lathes, and grinding equipment. A modern welding shop is located in the same area which has T/G and MiG equipment along with furnaces for heat-treating materials. A heavy duty machine shop and complete repair facilities are maintained in the TERA compound just west of the campus. The machine shop includes: a gun lathe, vertical mills, boring mills, and other heavy duty machinery. These facilities are fully staffed by personnel capable of fabricating virtually any required test fixtures or target simulators and of maintaining all test equipment.

LOGISTICS SUPPORT CAPABILITY

The TERA Group has extensive on-site logistics support capability including storage facilities for large quantities of all types of ammunition, propellants, explosives, and other hazardous materials. Large numbers of obsolete aircraft, armored vehicles, and general purpose vehicles as well as a variety of nonvehicular target materials are available at the site. Large quantities of various types of sheet metal are on hand for fabricating special target simulators. Complete ammunition loading facilities are available.

Calibration facilities include:

1. Pressure. A CEC type 6-201-0001 Primary Pressure Standard is available for use in calibrating pressure-sensitive instruments within the range of 0.3 to 500 psi. This primary pressure standard has a resolution of 0.002% of reading at any pressure within the range of the instrument and an accuracy of within 0.015% of reading in the lower pressure ranges and within 0.025% of reading the higher pressure ranges.

2. Acceleration. A drop ball machine is used in the comparison mode. The standard accelerator is an Endevco Model 2225.

3. Temperature. The temperature sources used for calibration are fixed and variable temperature baths. Reference thermocouples are used to measure the temperature accurately.

4. Frequency and Time. Frequency and time calibrations are made using National Bureau of Standards transmissions (WWV).

5. Voltage, Current and Resistance. Voltage, current and resistance calibrations are made via secondary standards traceable to NBS. The NMIMT Instrument Laboratory maintains these secondary standards on a scheduled basis by utilizing the services of a primary standards laboratory located in Albuquerque, NM.

INDOOR FACILITIES

No indoor test facilities are available.

OUTDOOR FACILITIES

BLUE CANYON FIELD LABORATORY

The Blue Canyon Field Laboratory is the main testing and instrumentation complex. It has been designed for high explosive and gunfire studiés and is suitable for a variety of investigations.

CLIFF SITE

Dimensions

The Cliff Site is a unique test facility which uses a natural 200-foot cliff for free-fall drop tests and air-to-surface simulation for testing gun-fired projectiles. (Figure DD-2 shows the Cliff Site.)

Weapons/Projectiles Available

Weapons available for use of this site include standard .30 and .50 caliber and 20-, 23-, and 30-mm rifled barrels; special 20-mm barrels with one twist in 20, 18, 16, 14, 12, 10, and 8 inches; a high twist 23-mm barrel; a special 30-mm barrel; and 20-mm smooth-bore barrels chambered for 20- and 40-mm cartridges.

Projectiles available for the above weapons include a complete range of operational rounds. The TERA Group has the capability to fabricate sabots for any of the barrels for launching fragments or test projectiles.

Environment

Only ambient conditions are used on this range.

Live/Inert Fire

High explosive projectiles can be fired from 30-mm or smaller weapons.

Safety (and Security) Requirements

The TERA Group holds a Secret facility clearance and can accommodate materials and equipment of that classification.

Rigorous safety precautions are enforced at all times. A system of sirens, warning lights, and flags is used for warning range personnel when test firings are to be conducted. Barriers and warning lights on all roads leading into the test preclude accidental entrance into danger areas.

Power Availability

Commercial electrical power of 110 and 220 VAC is available at the test site. Portable generators are available for providing other types of electrical power.

Observation/Communication

Direct observation of tests conducted at the Cliff Site is possible from several safe vantage points. Telephone communication is available at the site.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. Accurate in-flight ballistics data can be recorded from several aspect angles by the motion picture cameras listed in Table DD-I. Start and stop functions for these cameras are initiated by a 12-channel preset digital counter which is controlled by the field safety officer.

In addition, still cameras are available for documentary coverage, including open-shutter techniques during high-speed events.

TIMING. The central element of the TERA timing system is a 12-channel preset digital counter. This counter initiates all test events, instrumentation start and stop functions and provides a common time base for all instrumentation systems. One of the velocity measuring systems used at NMT/TERA is a photoelectric break-type circuit. The sensors are phototransistors, with rise and fall times of 3 μsec. The outputs of these transistors are used to start and stop the digital μsec counters. The two sizes of grids available are: 9 by 12 feet, and 8 by 12 inches.

HARDWIRE/TELEMETRY. All electronic data are transmitted by hardwire systems to the instrumentation center. In the instrumentation center the data can be routed to either of two magnetic-tape-recording systems. One can operate either as a direct system with 14 channels (100 to 300 kHz, 60 to 17/8 in/sec) or 14 FM channels, DC to 20 kHz. Both recorders are normally run at 60 in/sec but have a range from 60 to 1-7/8 in/sec. Data can also be patched to a 12-channel oscillograph (DC to 2500 kHz, 60 to 1/4 in/sec), to oscilloscopes or to high-speed cameras. Along with the data there are also a 1-kHz timing signal and a voice channel stored on the magnetic tapes. The data are played back from tapes, at a speed reduction of 32, onto a high-speed 12-channel (DC to 2500 kHz, 60 to 1/4 in/sec) oscillograph. Through use of direct print paper, a hard copy record can be available in 60 seconds.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. Impact data are recorded by the motion picture cameras listed in Table DD-I or still cameras.

TIMING. 1-kHz timing marks are recorded on both sides of the motion picture film by separate channels of the digital counter.

HARDWIRE/TELEMETRY. Sensors such as pressure transducers or accelerometers can be used for terminal ballistic measurements. The outputs from these sensors is transmitted to the instrumentation center and recorded in the manner described previously.

GUN FIRING SITE

Dimensions

This site provides for firing at ranges of up to 200 feet. Several firing points are established at this site which permit the conduct of multiple tests on a near simultaneous basis. Figure DD-3 shows the arrangement of the site.

Weapons/Projectiles Available

The weapons available for use on this site are listed in Table DD-2. A complete array of projectiles ranging from full scale operational rounds to sabot propelled fragments are available.

Environment

Tests at this site are conducted under ambient conditions.

Live/Inert Fire

High explosive rounds up to 30-mm may be fired on this facility. Inert projectiles up to 120-mm may be fired.

Safety (and Security) Requirements

The previously discussed factors apply to this site.

Power Availability

Commercial power of 110 and 220 VAC is permanently available at this site. Other voltages are provided by portable generators if required.

Observation/Communication

Direct visual observation is possible from several safe vantage points. Telephone communication is available.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The cameras listed in Table DD-1 are all usable at this site. The timer system and electronic velocity grids previously described are also used at this site.

TIMING. The system previously described is also used at this site.

HARDWIRE/TELEMETRY. The hardwire data transmission and recording system previously described is also used at this site.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. In addition to the motion picture cameras listed in Table DD-1 and a variety of still cameras, a 300 MW Fractional-μsec Cineradiography X-ray System is used on this site for collecting terminal ballistic data.

The flash x-ray system is designed to generate a high-intensity x-ray beam, to take short-duration x-ray pictures, in rapid sequence, through dense materials. Three separately controlled channels may be fired simultaneously, or in any desired sequence. This equipment can be used for investigating impact phenomena and other effects related to the detonation of high explosives.

Pulse durations are 1.0 and 0.2 μsec, and the interpulse periods are variable from 1.0 μsec to approximately 1 minute. Pulses of current of up to 1000 amperes are supplied to the x-ray anode, through a triggered spark gap, at 300 kV, by a pulse transformer whose primary is fed from either of two pulse generation circuits, depending on choice of pulse duration. Efficiency of the pulse transformer is enhanced by the use of DC bias-supply. The capacitors of the pulse generation circuits are, in turn, charged to 65 kV by a high voltage power supply.

Operation of the system is initiated by a signal from a detonator, or other external source, which passes to an oscilloscope whose controllable-delay-characteristic permits variable trigger times. The output of the scope in each channel is fed to a trigger amplifier which, in turn, initiates the spark-gap discharge.

TIMING. The timing system described in the previous section is used on this site.

HARDWIRE/TELEMETRY. The data collection system previously described is used on this site.

STRUCTURAL TESTING COMPLEX

Dimensions

Firings can be conducted at ranges of up to 200 feet. Figure DD-4 shows this complex.

Weapons/Projectiles Available

Of the weapons listed in Table DD-2, those through 30-mm can be fired in this complex.

Environment

Several test fixtures in this complex are used to apply loads, which simulate in-flight loads, to aircraft structures. Tensile, compressive and shear loads can be applied to simple and complex structural assemblies. Loads can be applied by hydraulic or pneumatic

cylinders with load values variables from zero to several million pounds. The stress distribution during the load cycle in the item under investigation is obtained from strain values measured by resistance-type strain gages. Explosives, explosive devices or propellant-loaded devices can be used to damage the structures during testing.

Live/Inert Fire

Live fire of up to 30-mm high explosive rounds can be conducted in this complex.

Safety (and Security) Requirement

The procedures previously discussed apply to this complex except that test personnel must remain in a control blockhouse during firings.

Power Availability

In addition to commercial 110 and 220 VAC, and generator power, hydraulic and pneumatic power are available.

Observation/Communication

No direct visual observation is permitted during tests in this complex. Telephone communication is available in the blockhouse.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The motion picture cameras listed in Table DD-1 and an assortment of still cameras are available for use at this complex.

TIMING. The timing system and electronic velocity screens previously described are used in this complex.

HARDWIRE/TELEMETRY. The hardwire transmission and data recording system previously described is used for collecting terminal effects data at this site.

BALLISTICS EFFECTS DYNAMIC DATA DEVICE

Dimensions

Firing can be conducted at ranges of up to 200 feet.

Weapons/Projectiles Available

Of the weapons listed in Table DD-2, those through 30-mm can be fired on this site.

Environment

The BEDDD (Ballistic Effects Dynamic Data Device), developed by NMT/TERA (in cooperation with the Naval Weapons Center, China Lake, CA), is a device to produce supersonic, in-flight conditions on aircraft sections, for the purpose of conducting damage-effect studies and other tests.

The two conventional methods of providing experimental airflow for a target are flight test and wind tunnels. Neither of these methods is suitable for damage or vulnerability tests because flight-test objectives are rarely compatible with determination of the aerodynamic effects on a damaged target, and they are prohibitively expensive. The inherent danger to a wind tunnel structure renders existing wind tunnels unsuitable for damage tests that require firing of warhead-type devices.

A "hard-construction" type of blowdown device, the BEDDD consists of three 23,000-gallon LOX containers welded together to form a 115-foot long, 10-foot-diameter stainless steel tank assembly (pressure chamber). Through the controlled ignition of the fuel contained therein, the device is designed to produce a gas-flow output that is capable of generating the equivalent of a Mach-2 aerodynamic environment, for about 140 msec, upon the selected aircraft structure that is in the flow. The fuel is kerosene, explosively dispersed into the tank atmosphere which has been enriched by oxygen, at ambient temperature and pressure.

Live/Inert Fire

High explosive projectiles of up to 30-mm can be fired at this facility.

Safety (and Security) Requirements

The procedures previously discussed apply to this facility except that test personnel must remain in a control blockhouse during firings.

Power Availability

Commercial power of 110 and 220 VAC are available at the site.

Observation/Communication

Direct visual observation is not permitted during firing tests at this site. Telephone communication is available in the blockhouse.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The motion picture cameras listed in Table DD-1 and an assortment of still cameras are available for use at this facility.

TIMING. The timing system and electronic velocity screens previously described are used on this range when precise projectile velocities are required.

HARDWIRE/TELEMETRY. The hardwire data transmission and recording systems previously described are used at this site.

Terminal Ballistic Instrumentation

LASER/PHOTOGRAPHY. All previously described motion picture, still cameras and x-ray systems can be used to collect terminal effects data at this facility.

TIMING. The previously described timing system can be used in conjunction with appropriate sensors to record terminal ballistics data.

HARDWIRE/TELEMETRY. The previously described hardwire transmission and recording systems are used for collecting terminal effects data at this facility.

VALLEY SITE

The Valley Site is an outdoor facility used for firing projectiles over longer ranges than can be achieved in the Blue Canyon facilities.

Dimensions

This outdoor facility provides for firing at a range of 1500 meters.

Weapons/Projectiles Available

All weapons listed in Table DD-2 can be fired on this site. Full scale operational rounds as well as sabot launched subcaliber projectiles can be used.

Environment

Testing at this site is conducted under ambient conditions.

Live/Inert Fire

High explosive rounds of up to 152-mm may be fired at this site.

Safety (and Security) Requirements

The main access road to the Blue Canyon and West Valley complexes passes under the trajectory of projectiles fired at this site. Barricades are used to block the road when testing is in progress.

Power Availability

Commercial 110 and 220 VAC are available at this site. Additional power requirements can be met by portable generators.

Observation/Communication

Direct visual observation of tests is possible from safe vantage points near the firing point. Telephone communications are available at the site.

In-Flight Ballistic Instrumentation

LASER/PHOTOGRAPHY. The motion picture and still cameras previously described can be used at this site for collecting in-flight ballistic data.

TIMING. At the present time there are three mobile units at NMT/TERA. Two designed for measurements of velocity, only, and the other for both pressure-time and velocity measurements.

1. Velocity Van. Contained, therein, are all power supplies, amplifiers and digital equipment that is used in conjunction with the (photoelectric) velocity grids previously described.

2. Velocity/Pressure Van. In addition to the velocity measuring equipment contained (as above), a 12-channel oscillograph recorder (DC to 2.5 kHz or 1 to 160 in/sec) and the associated conditioning equipment.

HARDWIRE/TELEMETRY. All instrumentation used at this site is hardwired to the mobile instrumentation units.

Terminal Ballistic Instrumentation

No economical means for collecting impact data is available at this site. The motion picture and still cameras described in previous sections can be used, but the installation of these or other systems at the target location involves considerable time and expense.

WEST VALLEY TEST FACILITY

The most recent addition to the TERA Field-Laboratory complex is the West Valley Test Facility. This facility is located approximately 1/2 mile west of the Blue Canyon test area.

Dimensions

Firing can be conducted at ranges of 100, 200, 300, 500, and 1000 meters at this outdoor site.

Weapons/Projectiles Available

All weapons listed in Table DD-2 can be fired at this site. Full scale operational rounds as well as sabot launched subcaliber projectiles can be used.

Environment

All testing at this facility is conducted under ambient conditions.

Live/Inert Fire

Live fire of up to 152-mm high explosive rounds can be fired on this facility.

Safety (and Security) Requirements

The natural backstop provided by surrounding hills permit firing at this facility without interrupting operations in the Blue Canyon complex. The safety procedures previously described apply to this facility.

Power Availability

Commercial 110 and 220 VAC electrical power is permanently installed at the facility.

Observation/Communication

Direct visual observation is possible from safe vantage points near the firing point. An intercommunications system links each firing site and the target area.

Instrumentation

The same instrumentation capability is available as was described for the Gun Firing Site.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The data collected at the TERA facilities are in the form of photographs (optical or x-ray), oscilloscope traces, analog recordings on magnetic tape and high-speed film. These data are manually reduced, key punched and stored on magnetic tape or disks.

QUICK-LOOK CAPABILITY

Black and white film is processed inhouse and can be completed within 1 hour. Color film required 24 hours for processing by a commercial processor. Data analysis is performed by an inhouse computer for which normal turnaround is less than 1 hour.

PROCESSING

System and Model

The TERA Group has unlimited access to the IBM 360/40 computer system which is located on the campus of the Institute in the same building in which the TERA offices are maintained. Peripheral devices include a high-speed card reader, line printer, four magnetic tape units, two high-speed disk units and a Calcomp X-Y plotter.

Language

The computer system is sufficiently flexible to permit the use of any standard language.

Input/Output Options

Input is normally through punch cards and output may be either by line printer or plotter.

Realtime/Interaction

No realtime computing capability exists at these facilities.

DISTRIBUTION

As previously discussed, very short turnaround times are normal in this facility.

REGION C (FOREGROUND) AND REGION A (BACKGROUND)
BLUE CANYON FIELD LABORATORY

A - REGION A, WEST VALLEY
G - TARGET-STORAGE AREA
H - FRAGMENT-RECOVERY AREA
J - ORDNANCE-STORAGE SILOS
K - MACH-2, BALLISTIC EFFECTS DYNAMIC DATA DEVICE
L - INSTRUMENTATION COMPLEX AND X-RAY SYSTEM

Figure DD-1. Overview of TERA Test Facilities.

Figure DD-2. Cliff Site.

A - SMOOTHBORE GUN
B - TARGET-SITE FOR SMOOTHBORE, WITH X-RAY MONITORING
C - GUN LINE
D - GUN LINE
E - INSTRUMENTATION/PERSONNEL SHELTER
F - RIO GRANDE VALLEY

Figure DD-3. Gun-Firing Test Site.

A - FUSELAGE/WING STRUCTURAL-TESTING FIXTURE
B - TENSILE-PANEL TESTING FIXTURE
C - COMPRESSION-PANEL TESTING FIXTURE
D - FUSELAGE/WING STRUCTURAL-TESTING FIXTURE
E - INSTRUMENT/PERSONNEL SHELTER
F - INSTRUMENT/PERSONNEL SHELTER
G - CLIFF SITE

Figure DD-4. Structural-Testing Complex.

Table DD-1. Motion Picture Cameras Available.

Make	Film		Rate, frames/sec
	Size, mm	Capacity, ft	
Bell and Howell	16	100 and 400	8 to 64
Bolex	16	100	8 to 64
Cine-Special II	16	100	8 to 64
K-100	16	100	64
Mitchell	16	400	8 to 144
Fastex split frame	16	100	1000 to 16,000
Fastex full frame	16	100 and 400	500 to 8000
Bell and Howell	35	100 and 400	6 to 200
Photosonic	35	500	250 to 1800
Fastex split frame	35	100	500 to 600

Table DD-2. Weapons Available at TERA.

Weapon	Special features
.30 caliber	
.50 caliber	
20 mm	
23 mm	
30 mm	
40 mm	
75 mm	
90 mm	
105 mm	
152 mm	
155 mm	
120 mm	Smooth bore-double length
20 mm	One twist in 20 inches
20 mm	One twist in 18 inches
20 mm	One twist in 16 inches
20 mm	One twist in 14 inches
20 mm	One twist in 12 inches
20 mm	One twist in 10 inches
20 mm	One twist in 8 inches
20 mm	Smooth bore chambered for 20 mm cartridge
20 mm	Smooth bore chambered for 40 mm cartridge
23 mm	High twist rifling
105 mm	Smooth bore

ANNEX EE - INTRODUCTION

OVERVIEW

The administrative and engineering offices of PATEC (Pacific Technical Corporation) are located at 415 East Montecito Street in Santa Barbara, CA.

For the past 13 years PATEC has been engaged in the development of advanced warheads and projectiles. Particular emphasis has been directed toward conceptual design, prototype development and manufacture of armor piercing discarding sabot ammunition and related components. This effort also included pioneering work in the employment of depleted uranium alloys and similar advanced high density materials for ordnance applications. A major program was directed toward the development of spin stabilized discarding sabot ammunition for use with automatic weapons.

The ballistic test facilities maintained by PATEC are primarily used to support the above work but they are available for other survivability/vulnerability testing.

The primary point of contact concerning testing in the PATEC facilities is Dr. Fritz K. Feldmann, President, telephone 805-965-4581.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The PATEC facilities have been used primarily to test various structural materials instead of systems or subsystems. The facilities do, however, lend themselves to the test of complete aircraft systems or any subsystems.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

PATEC maintains and operates one indoor facility, located at the Santa Barbara Airport, and one outdoor facility, located at Camp Roberts, CA (125 miles north of Santa Barbara). Each of these facilities has the necessary space, equipment and instrumentation for a broad spectrum of S/V testing.

ACCESS

Excellent access is provided the PATEC Santa Barbara facilities by Highway 101, the Southern Pacific Railroad and the Santa Barbara Airport and to the Camp Roberts facility by Highway 101 and the Southern Pacific Railroad.

MAINTENANCE/FABRICATION CAPABILITY

Very limited maintenance and fabrication is organic to PATEC. An ample number of vendor organizations are available in Santa Barbara to perform these functions.

LOGISTICS SUPPORT CAPABILITY

PATEC has storage facilities for depleted uranium penetrators and for up to 200 pounds of propellant. Complete loading facilities exist for up to 40-mm ammunition.

INDOOR FACILITIES

DIMENSIONS

The PATEC indoor range occupies over 1100 ft^2 of enclosed space. Figure EE-1 shows the range layout. Projectiles of up to 23-mm can be fired at velocities of up to 4500 ft/sec on this range.

WEAPONS/PROJECTILES AVAILABLE

The weapons and barrels available at the PATEC facility include those listed in Table EE-1.

Projectiles available include standard military ammunition for every size barrel and special projectiles such as depleted uranium, tungsten and discarding sabot.

ENVIRONMENT

All tests are conducted under ambient conditions.

LIVE/INERT FIRE

Armor piercing incendiary rounds of up to 23-mm can be fired on this range. No high explosive projectiles can be fired.

SAFETY (AND SECURITY) REQUIREMENTS

PATEC holds a Secret facility clearance and can accommodate documents and materials of that classification.

All firing is done electrically from a protected control position. No warning system is employed. Safety is assured by limiting the number of personnel involved in tests and physically accounting for all test personnel before firing.

POWER AVAILABILITY

Only 110 and 220 VAC commercial power is installed on the range.

OBSERVATION/COMMUNICATION

Observation ports in the side wall of the range permit visual observation or photographic coverage from a protected position.

No range communications are provided.

IN-FLIGHT BALLISTIC INSTRUMENTATION

Laser/Photography

Photographic instrumentation available at the PATEC range includes Fastex high-speed motion picture cameras, still cameras, flash x-ray units, Schlieren units, multiple microflash units and 16-mm motion picture cameras for normal speed or slow motion photography.

Timing

Paper make velocity screens provide triggering for electronic counters or oscilloscopes for measuring projectile velocities.

Hardwire/Telemetry

All instrumentation is connected by hardwire circuits.

TERMINAL BALLISTIC INSTRUMENTATION

Laser/Photography

The photographic systems described above are also used for collecting data concerning terminal effects.

Timing

Sensors of various types are used in conjunction with oscilloscopes to measure terminal effects.

Hardwire/Telemetry

All instrumentation systems are connected by hardwire circuits.

OUTDOOR FACILITIES

DIMENSIONS

The Camp Roberts facility can accommodate firing over ranges of up to 2000 meters. Figures EE-2, EE-3, and EE-4 show typical test layouts for this facility.

WEAPONS/PROJECTILES AVAILABLE

All weapons listed in Table EE-1 can be fired on this range.

ENVIRONMENT

All tests are conducted under ambient conditions. Night firing can be conducted by prior arrangement.

LIVE/INERT FIRE

High explosive projectiles of up to 30-mm can be fired on this range by arrangement with the California National Guard provided the ammunition is government furnished. Larger calibers may be fired through special arrangement with range control.

SAFETY (AND SECURITY) REQUIREMENTS

The same requirements pertain as were described above.

POWER AVAILABILITY

Commercial power of 100 VAC is available to some points at this facility. Mobile generators are used to provide 110 and 220 VAC to other sites.

OBSERVATION/COMMUNICATION

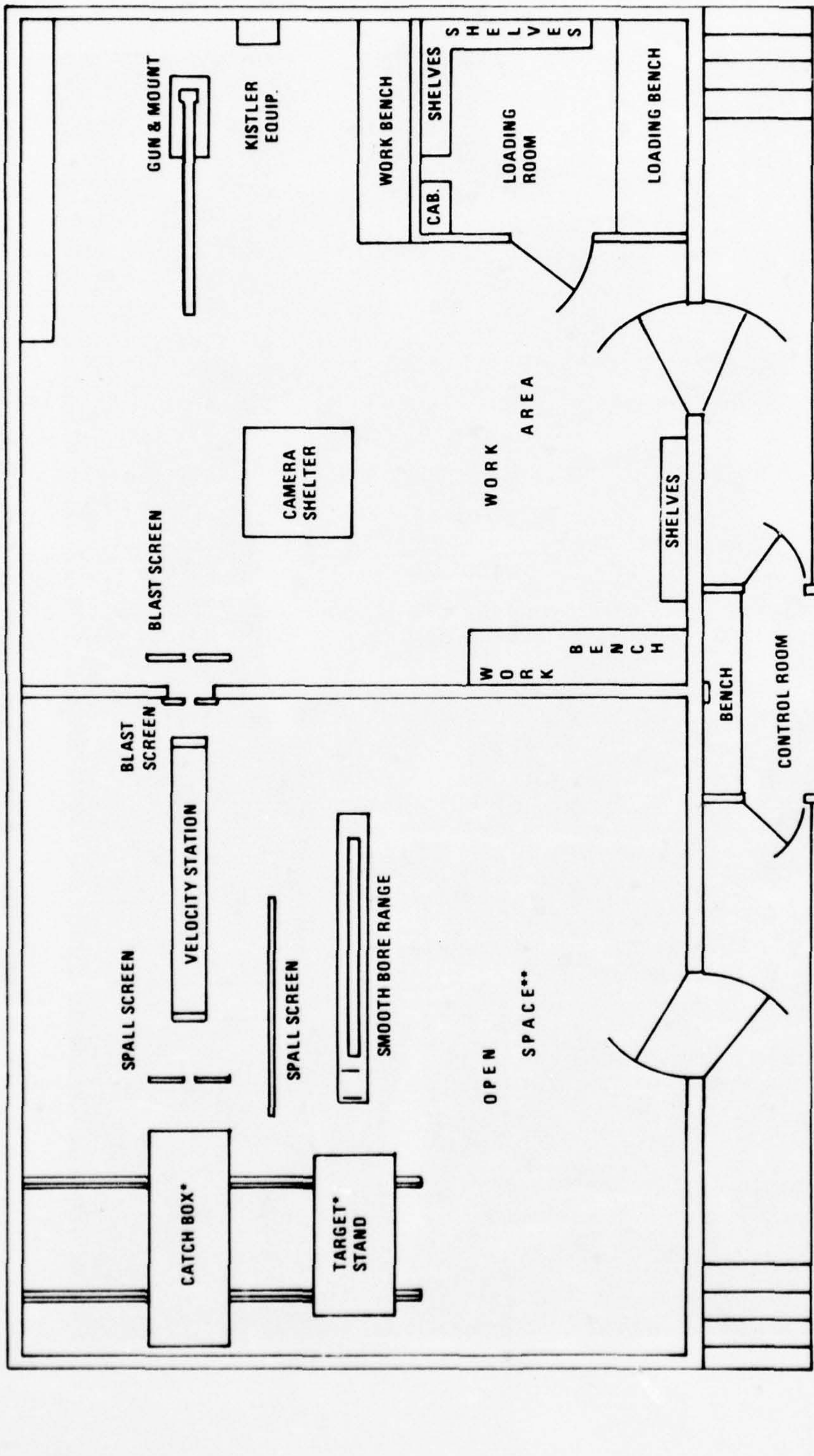
Direct visual observation is permitted from the vicinity of the firing point. Field telephones provide communication between the firing point, any remote observers and range control.

INSTRUMENTATION

In addition to the instrumentation described for the indoor facility measurements are normally made of terminal velocity and of the time of flight of the projectile.

DATA HANDLING/PROCESSING

All data are manually reduced and processed. A Wang Model 360 programmable calculator is used for data analysis.



SCALE: 3/16 INCH = 1 FOOT
*ON RAILS **FOR FUTURE EXPANSION

Figure EE-1. PATEC Indoor Test Facility.

Figure EE-2. Typical Test Layout for Camp Roberts.

Figure EE-3. Typical Target Rig.

Figure EE-4. Overview of Camp Roberts Test Area.

Table EE-1. Weapons Available at PATEC.

Weapon	Type
.22 caliber	Smooth bore
.625 caliber	Smooth bore
.85 caliber	Smooth bore
5.56 mm	Rifled
7.62 mm	Rifled
.50 caliber	Rifled Mann barrel
.50 caliber	Rifled machine gun barrel
20 mm	Rifled Mann barrel
20 mm	Rifled M139 machine gun barrel
20 mm	Rifled M139 machine gun
20 mm	Rifled HS804 machine gun
20 mm	Rifled MK12 barrel
20 mm	Rifled Mann barrel M50 series
23 mm	Rifled HS823 barrel
23 mm	Rifled Mann barrel
30 mm	Rifled GAU 8 barrel
30 mm	Rifled Mann barrel
40 mm	Rifled Bofers barrel

ANNEX FF - INTRODUCTION

OVERVIEW

The U.S. Army Picatinny Arsenal is located in Dover, NJ, 1/2 mile north of U.S. Route 80 on New Jersey Route 15. Located in a valley between the Copperas and Green Pond Mountains in the highlands of New Jersey, the Arsenal is ideally suited to the conduct of research on explosives and munitions. The physical plant includes 6491 acres of land and almost 4 million ft^2 in buildings and structures. The Arsenal functions as a development center for the Army for all ammunition (exclusive of chemical), up to and including 8-inch projectiles. Areas of responsibility include nuclear munitions (less nuclear components), conventional munitions, artillery and recoilless rifle ammunition, bombs, mines, grenades, explosives, demolitions and firing devices. The primary point of contact for this facility is Mr. Ronald Geany, telephone 201-328-5466.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

All aircraft systems can be tested at the Arsenal, including ordnance with an explosive equivalent of up to 25 pounds HE (cased). Gelatin blocks are also used to simulate tests of personnel vulnerability.

SURVIVABILITY/VULNERABILITY OVERVIEW

Three ranges of Picatinny Arsenal are suitable for survivability/vulnerability type testing. One indoor range 160 feet long can be used to fire inert projectiles up to 20-mm. Two outdoor ranges provide a capability of firing inert projectiles up to 8-inch caliber and HE projectiles up to 106-mm. Targets may contain explosives of up to 25 pounds HE (cased) equivalent. Depleted uranium projectiles may be fired. Multiple areas for static detonation of explosives are also available.

ACCESS

Access to the Arsenal is by road, rail, or helicopter. The Arsenal is located on State Route 15, approximately 0.5 mile north of Interstate Route 80. Newark Airport is 35 miles southeast; Morristown Airport is approximately 15 miles south.

MAINTENANCE/FABRICATION CAPABILITY

The maintenance and fabrication capability of the Picatinny Arsenal is extremely good. Arsenal personnel are qualified to fabricate and maintain not only required jigs and fixtures, but also all manner of ordnance including fuses. A limited maintenance and repair capability for aircraft systems and subsystems exists at the Arsenal and it can be supplemented by elements of the New Jersey Air National Guard. (A helicopter detachment is scheduled to be located at the Arsenal in the coming year.)

LOGISTICAL SUPPORT CAPABILITY

Storage and reloading facilities exist in abundance for all types of ordnance at the Picatinny Arsenal. Experimental and developmental ordnance can also be designed and produced.

INDOOR FACILITIES

RANGE NUMBER 620

Dimensions

This range, also known as the Small Arms Range, is 12 feet wide, 9 feet high, and 160 feet long. Walls are concrete and the roof is corrugated steel. A 12- by 15-foot instrumentation room is adjacent to the firing lane and a bullet catcher is located at the end.

Targets must be nonflammable and must pass through a 4- by 8-foot door. Gelatin blocks may be used to simulate tests against personnel.

Weapons/Projectiles Available

Projectiles up to 20-mm may be fired on this range. Mann barrels from .22 caliber through 20-mm are available. In addition, all small caliber small arms are also available.

Live/Inert Fire

Inert projectiles only may be fired.

Safety (and Security) Requirements

The area is secure for classified materials. Range doors are provided with safety interlocks. Range safety requirements are available upon request.

Power Availability

Electrical power up to 220 volt, single-phase is available. DC power for normal aircraft usage can be provided. Plant . (100 psi) is available. Hydraulic power can also be provided.

In-Flight Ballistic Instrumentation

PHOTOGRAPHY. Twelve Fastex high-speed cameras are available for use as either full frame (8000 frames/sec) or half frame (16,000 frames/sec) cameras. 100-foot magazines are used. One Photosonic (1000 frames/sec) and one Milliken (500 frames/sec) are also available in addition to standard movie cameras and one streak camera. Multiple microflash units can also be employed.

Multiple flash x-ray units of 100, 300, and 600 kV can be used. One 2.3 mV head is also available.

TIMING. 1000 Hz timing mark generators are used for camera timing. Light screen, paper grid and magnetic impulses are used with chronographs for in-flight timing.

HARDWIRE. Standard gun function instrumentation is used to record pressure-time histories for chamber and barrel pressures. Two 80 kHz, 14-channel recorders are available for recording 12 data channels, one time base channel and one voice channel. Multiple magnetic tape recorders of lower response are also available. Dual beam storage oscilloscopes and oscillographs may also be used.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. See In-Flight photographic capability.

TIMING. See In-flight timing capabilities.

HARDWIRE. Terminal hardwire instrumentation capability includes measurement of pressure, temperature and strain.

OUTDOOR FACILITIES

RANGE NUMBER 636

Dimensions

This outdoor range is 400 feet long and terminates in a slug butt 12 by 12 feet, 20 feet deep. Target materials are placed by forklift. A 30- by 50-foot building for personnel and range instrumentation is located behind a barricade.

Weapons/Projectiles Available

Projectiles up to 8-inch caliber may be fired. All U.S. weapons from 20-mm through 8-inch caliber are available.

Live/Inert Fire

Inert projectiles only may be fired.

Safety (and Security) Requirements

The range is secure for classified materials and weapons. Range safety requirements are available on request.

Power Availability

Electrical power up to 220 volts is available at the range building. DC electrical power and hydraulic power can be provided by portable generators.

Observation

No live observations are allowed.

Instrumentation

The instrumentation used for survivability/vulnerability testing is portable. See the instrumentation capabilities of Range Number 620 (INDOOR FACILITIES).

RANGE NUMBER 1242

Dimensions

This outdoor range is 400 feet long and terminates in a slug butt 30 feet wide, 20 feet high, and 30 feet deep. Targets are placed by forklift. An instrumentation/personnel van is located behind a barricade. Targets which can be fired at are limited only by the size of the slug butt. They may contain an explosive equivalent of up to 25 pounds HE (cased). Fuel tanks may be fired at.

Weapons/Projectiles Available

See Availability for Range Number 636.

Live/Inert Fire

HE projectiles up to 106-mm may be fired. Inert projectiles up to 8-inch caliber may be fired.

Safety (and Security) Requirements

This range is secure for classified materials and weapon systems. Range safety requirements are available on request.

Power Availability

Electrical and hydraulic power requirements can be met with portable generating equipment.

Observation

No live observation is allowed.

<u>Instrumentation</u>

The instrumentation used for survivability/vulnerability testing is portable. See the instrumentation capabilities of Range Number 620 (INDOOR FACILITIES).

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data is stored on film, computer card, magnetic tape, or disk.

QUICK-LOOK CAPABILITIES

Quick-look capabilities are limited to oscillograph, oscilloscope, and strip chart recordings.

PROCESSING

<u>System and Model</u>

A CDC Model 6500 digital computer is located at the Arsenal. An Analog-Hybrid Computer (EAI 8800) is also available.

<u>Languages</u>

All common languages can be accommodated.

<u>Input/Output Options</u>

Standard I/O options are available. Either 7- or 9-track magnetic tapes can be used. In addition, numerous remote terminals may be used in a remote batch or time-sharing mode. Several interactive graphics terminals are available.

<u>Realtime Interaction</u>

Time-sharing mode can be used in addition to interactive graphics terminals.

DISTRIBUTION (TURNAROUND TIME)

Turnaround times ranges from immediate to several hours, depending upon the job size and processing time required.

ANNEX GG - INTRODUCTION

OVERVIEW

Over the past several years, the LAAD (Los Angeles Aircraft Division) of Rockwell International has established a capability for carrying out all phases of research and development in the area of ballistic testing at the Rocketdyne/Santa Susana Field Laboratories, located in a remote area approximately 10 miles from the Canoga Park headquarters. The mountainous terrain readily provides ideal backstops for the gun ranges, and permits easy control of high-velocity and/or high-energy projectiles. The area contains two buildings with temperature and humidity control which are provided with reinforced concrete walls for personnel protection.

Rockwell International is particularly well qualified and equipped to obtain data on secondary impacts. This expertise and ballistic test range equipment/instrumentation are a result of having performed ballistic testing for verification of penetration equations and residual velocity models in support of the B-1 aircraft program over a period of several years. Additional ballistic testing has been accomplished during this same period to support contracted efforts to the Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, VA, and several industrial organizations. The primary point of contact concerning testing at this facility is Mr. Glen Artz, telephone 213-884-4000.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

Rockwell International can perform S/V testing on materials, components, structure sections.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Three gunfire test ranges exist at the Rocketdyne/Santa Susana Field laboratories. Two outdoor ranges are nearly parallel and share the same control center. AP and HE weapons up to 40-mm may be fired at targets up to 350 feet downrange. The third range is located a short distance away from the other two and is housed in an 8-foot-diameter steel tunnel 110 feet long. Weapons up to and including 30-mm (23-mm HE) have been used for test in this facility.

ACCESS

The Santa Susana facility may be reached easily via State Route 18 from either U.S. Route 101 (via State Route 27) or from Interstate Route 405 (via Devonshire St.). Rail transport via the Southern Pacific and air transport are available to Chatsworth and Los Angeles International Airport, respectively. Port facilities are available at Port Hueneme.

MAINTENANCE/FABRICATION CAPABILITY

Complete machine shops facilities are available at the Canoga Park headquarters with a virtually unlimited capability.

LOGISTICAL SUPPORT CAPABILITY

Facilities are available at the Santa Susana Field Laboratories for storage of up to 10,000 pounds of HE. Facilities are available for loading cartridges of commonly used calibers.

INDOOR FACILITIES

TUNNEL GUNFIRE RANGE

Dimensions

The Tunnel Gunfire Range is housed in an 8-foot-diameter by 110-foot-long, 1/2-inch-thick steel tunnel. An adjacent control center provides a recording center and fire control area for conducting gunfire tests. The steel tunnel permits complete control of the projectile throughout its entire flight. Since it is completely enclosed, tests can be run night or day in any kind of weather. Targets must be nonflammable. Figures GG-1, GG-2 and GG-3 show exterior, interior and plan views of this stage.

Weapons/Projectile Available

Standard military projectiles from 5.56- through 30-mm may be fired using a variety of rifled or smooth-bore barrels. Smooth-bore barrels are also used to launch saboted projectiles of various sizes and shapes at velocities from 1000 to well over 6000 ft/sec.

Live/Inert Fire

Live HEI projectiles up through 23-mm and inert projectiles up through 30-mm may be fired.

Safety (and Security) Requirements

Facilities are available for storage of classified material and equipment. Standard safety procedures are employed (including use of electronic firing, door interlocks, warning lights, bells and sirens, and a PA system).

Power Availability

Electrical power at 110, 220, and 440 VAC is available. Portable generators are used to meet special electrical or hydraulic power requirements.

Observation

The target cannot be directly observed during tests.

In-Flight Ballistic Instrumentation

PHOTOGRAPHIC. High-speed Fastex cameras with framing rates from 1000 to 15,000 frames/sec can be used to record test results. Also available is a TRW Model 26B image Converter camera modified to extend the conventional 80-μsec maximum time duration. This five-frame framing unit provides exposure times of 50 to 500 nsec. Exploding bridge wire and Xenon flash lighting units are available for either front or back lighting as required, along with Fresnal lenses for proper light focusing.

A Field Emission Corporation flash x-ray system, consisting of two 300-Kr heads and one 600-Kr head is available. Rockwell has developed a unique combined usage (with the image converter camera) that provides synchronized high-resolution optical and radiographic records of individual complex high-velocity impact events.

TIMING. Four solid-state electronic time interval counters capable of 20 msec time discriminations (two Systron-Donner Model 6151 and two Dana Model 8015B), and four others capable of 100 msec time discriminations (Systron-Donner Model 6250 0) are available.

HARDWIRE. Kistler Model 607C4 ballistic pressure transducers with matched Kistler Model 504 charge amplifiers can be used for gun pressure measurements.

Tektronix Model 55 dual beam oscilloscopes (3) and a Sangamo Model 4700, Sabre IV, 14-channel, high-speed tape recorder (120 in/sec) are used to record hardwire instrumentation measurements.

Terminal Ballistic Instrumentation

The instrumentation available for In-Flight Ballistic recording is also used to record terminal ballistic events.

Environmental Simulation and Measurement

Tests are conducted at ambient conditions only.

OUTDOOR FACILITIES

HAPPY VALLEY GUNFIRE RANGE

Dimensions

The Happy Valley Gunfire Range is actually two ranges nearly parallel (approximately 100 feet apart) which share the same instrumentation/control center. The maximum firing

range is approximately 300 feet on the lower range and 350 feet on the upper range. Projectiles are stopped (at the maximum ranges) by a hill approximately 50 feet higher than the impact elevation. Figures GG-4 and GG-5 show these ranges.

Weapons/Projectiles Available

The following weapons are available:

1. 40-mm Bofers action with 30-mm smooth-bore barrel
2. 30-mm smooth-bore Mann barrel
3. 30-mm rifled Mann barrel
4. 26-mm rifled Mann barrel
5. 20-mm rifled Mann barrel
6. 14.5-mm rifled Mann barrel
7. 12.7-mm rifled Mann barrel
8. 5.56-mm rifled Mann barrel
9. Caliber .50 machine gun, rifled Mann barrel, and smooth-bore Mann barrel
10. Caliber .30 machine gun and various rifles

The Bofers gun is mounted at the lower range. Smooth-bore barrels have been used to launch projectiles of various sizes and shapes at velocities from 1000 to well over 6000 ft/sec.

Live/Inert Fire

Live projectiles may be fired.

Safety (and Security) Requirements

Facilities are available for storage of classified materials and equipment. Standard safety procedures are employed (including use of electronic firing, warning lights, bells, and sirens, and a PA system).

Power Availability

Electrical power at 110, 220, or 440 VAC is available. Additional requirements are met with portable generators.

Observation

No direct observation of a test is allowed. However, results can be observed on a closed circuit television system.

Instrumentation

See the Instrumentation section B for the indoor Tunnel Gunfire Range. The instrumentation which can be used at the Tunnel Gunfire Range normally is housed in the

control center for the Happy Valley Gunfire Range. In addition to the above instrumentation television monitors and a Sony PV-120u television video recorder can be used to provide immediate playback of test results.

Threats/Targets Available

Targets are customer furnished.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data are stored as photographic records or on magnetic tape. Computers are available but not normally used.

QUICK-LOOK CAPABILITIES

An immediate playback of test results from the television video recorder can be made. Playback from the high-speed tape recorder of recorded data at slower speeds into oscilloscopes at any desired signal sweep rates permites immediate detailed assessment of use rates, fluctuations, and/or instabilities.

PROCESSING

System and Model

Rockwell International's electronic digital computing facilities are centralized at the corporations' Space Division in Downey, CA. These include three IBM System 370 Model 165 computers, supported by peripheral equipment. Communication between the LAAD and the Space Division's computers is done over data transmission telephone lines and is performed from an IBM 360, Model 135 located at LAAD.

Remote terminals are also available for access to a CDC 6600 and a Honeywell 440 computer.

Language

FORTRAN H, PL/1, and COBAL are among the high level languages which can be processed by the IBM 370's.

Input/Output Options

All standard I/O options are available.

Realtime Interaction

Time-sharing is available on both the IBM 360 and the Honeywell 440 computers.

DISTRIBUTION (TURNAROUND TIME)

Turnaround time is entirely dependent upon the size of job and the mode of operation.

Figure GG-1. Tunnel Test Area - SSFL.

Figure GG-2. Gunfire Range with .50 Caliber Machine Gun in Place.

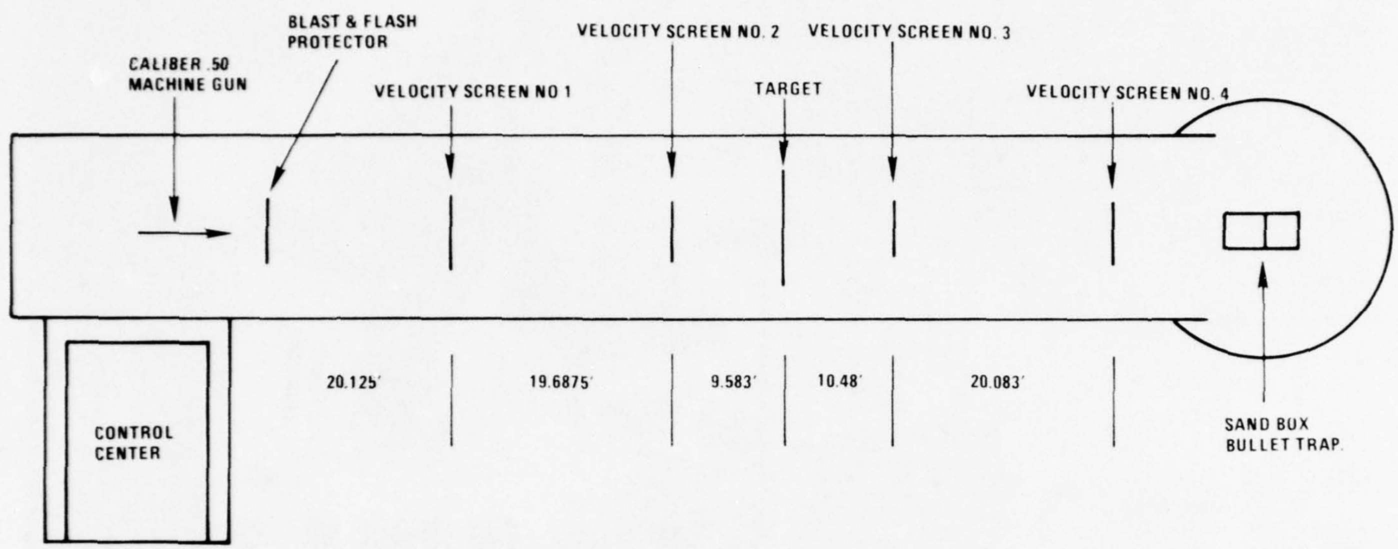


Figure GG-3. Test Setup for .50 Caliber Gunfire Tests into Composite Materials - Tunnel Area.

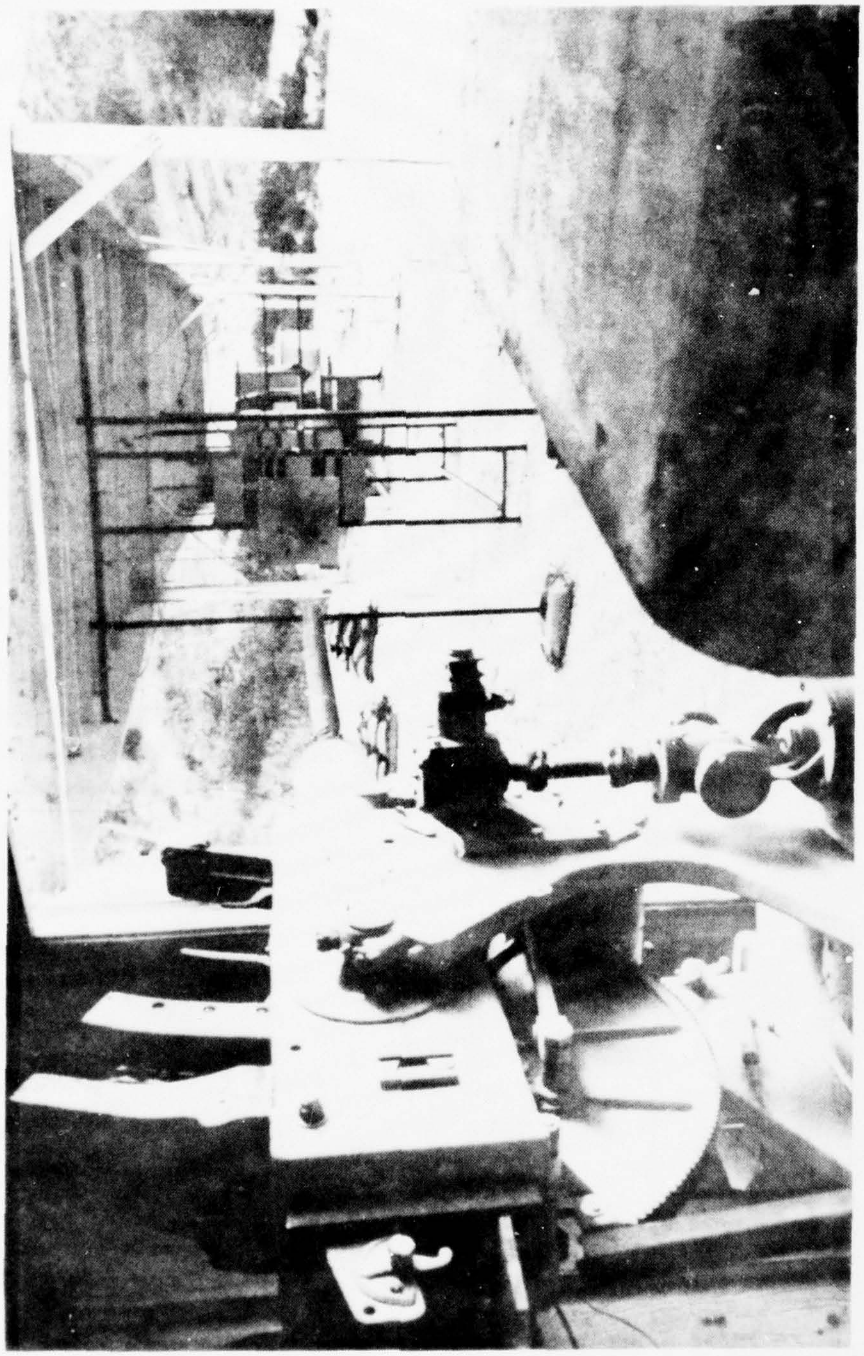


Figure GG-4. Happy Valley Gunfire Range (Lower).

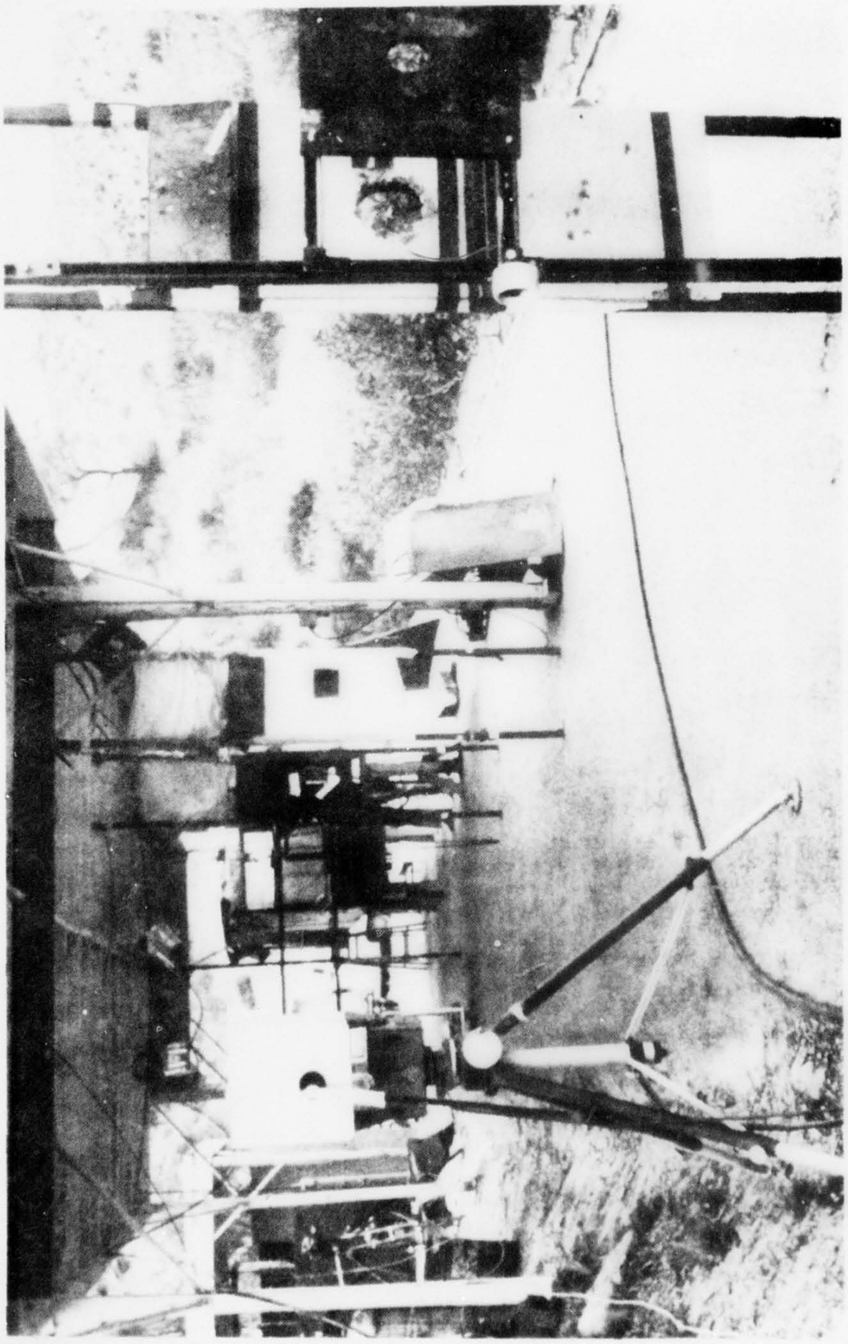


Figure GG-5. Happy Valley Gunfire Range (Upper).

ANNEX HH - INTRODUCTION

The Sandia Laboratories in Albuquerque, NM, operates indoor and outdoor ballistic test facilities. Sandia is part of the Energy Research and Development Administration whose mission is to perform research, development, testing, and evaluation of nuclear weapons systems and associated subsystems. Survivability/vulnerability testing for conventional weapons can also be performed.

Primary point of contact for the facility is Mr. D.C. Bickel, telephone 505-264-3178.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

The Sandia Laboratories' facilities are capable of testing all types of aircraft systems. Size of test item is virtually unlimited on the outdoor portions of the range. The Aerial Test Facility has potential for realistic S/V testing against IR guided weapons, radar guided weapons or radar directed weapons.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Sandia maintains two test facilities. Nonexplosive projectiles up to 20-mm may be fired on the gun range. Large weapons may be fired up to 15,000 feet on the Aerial Cable Test Range.

ACCESS

Sandia's Gun Facility is located on Kirtland Air Force Base, approximately 4 miles east of Interstate 25. The Aerial Cable Test Facility is located 6 miles east of the Gun Facility on Lurance Canyon Road. Rail transportation via the Atchison, Topeka, and Santa Fe Railroad is available to within 7 miles of the facility. Air transport is available to Albuquerque International Airport or Kirtland Air Force Base.

MAINTENANCE/FABRICATION CAPABILITY

A complete machine and metal working shop is available at the facility. Backup facilities are available at Kirtland Air Force Base, if needed. Electronic maintenance and fabrication capabilities are available for normal instrumentation.

LOGISTICS SUPPORT AND CAPABILITIES

Munitions storage facilities are available for virtually any amount of munitions. Logistics support for maintenance and repair of aircraft systems is available from Kirtland Air Force Base.

INDOOR FACILITIES

There are no strictly indoor test facilities. However, small guns may be fired indoors at the Guns Facility.

OUTDOOR FACILITIES

GUNS FACILITY

Dimensions

Sandia Laboratories' Guns Facility located in Area III on Kirtland Air Force Base consists of a bunkered instrumentation and control building adjacent to firing pits where powder guns and other blast and/or shrapnel-producing devices can be fired. Small guns (up to 20-mm, inert) can be fired inside or outside the facility. The building contains a machine shop and light laboratory equipment for test setup, fabrication, and assembly. Explosives storage igloos, and powder charge assembly building with a static-free room are located nearby. The areas adjacent to the building and 2.5 miles downrange have controlled access for hazardous test operations. Size of the test item is virtually unlimited.

Weapons/Projectiles Available

The available guns, gun parameters, types of projectiles available, and typical performance are shown in Table HH-1. Standard military and special propellant charges are used to control impact velocity within the pressure limits of the gun barrels. By using sabots as adapters, a wide variety of test shapes and sizes may be launched from the smooth-bore barrels.

Live/Inert Fire

Live HE projectiles may be fired outside the facility. HE projectiles larger than 20-mm may be fired using customer-provided barrels.

Safety (and Security) Requirements

The facility is located within a fenced, security area where classified items may be tested. A copy of the facility Safe Operating Procedure is available on request.

Power Availability

Commercial power (110 and 100 amp/440 volt) is available at the Facility. Portable generators are available as additional power sources.

Observation

HE tests cannot normally be observed directly.

In-Flight Ballistic Instrumentation

PHOTOGRAPHIC. High-speed photography with frame rates up to 30,000 frames/sec is available.

TIMING. Timing is accomplished with electronic timers.

HARDWIRE. A DATACOM projectile sensing system and RF telemetry is available for measuring gun and test unit parameters.

Terminal Ballistic Instrumentation

The above instrumentation can also be used for recording terminal effects.

Environmental Simulation and Measurements

Tests are conducted at ambient conditions.

AERIAL CABLE TEST FACILITY

Dimensions

The aerial cable facility consists of a wire rope stretched across a mountain canyon approximately 1 mile across. This cable is used for a trolly way on which a rocket propelled instrumented trolly travels at speeds of up to 400 knots. The trolly carries heat sources such as thermal pods or flares which serve as targets for infrared seeking missiles. The trolly is shown in Figure HH-1 and a typical missile firing is shown in Figure HH-2. Firing positions are available at ranges of up to 15,000 feet from the trolly.

Weapons/Projectiles Available

The weapons listed in Table HH-1 may be fired on this range. Larger caliber customer provided weapons may also be fired in addition to IR guided, radar guided, or radar directed weapons.

Live/Inert Fire

Live HE projectiles may be fired provided suitable arrangements have been made in the event of damage to the cable.

Safety (and Security) Requirements

The facility is cleared for classified material to the Secret level. Safety procedures are tailored to the test requirements.

Power Availability

Mobile generators are available for generating electrical power at 110, 220, or 440 VAC and 28 VDC.

Observation

Visual observation of tests is possible from several safe vantage points.

In-Flight Ballistic Instrumentation

PHOTOGRAPHIC. Fairchild, Fastex, and Mitchell cameras are available with framing rates of 70 to 4000 frames/sec. Cameras are furnished from the Field Test Photometric Department. In addition to numerous photometric stations on the ground, a separate aerial cable supports an aerial station for overhead views on test events. This arrangement permits a three-dimensional viewing of each firing. A laser tracker permits accurate positional measurements during the entire flight of the missile. These systems provide data concerning missile velocity, approach distance to the infrared source, time of flare ejection, trolly speed and event times.

TIMING. IRIG A and B time systems may be used.

HARDWIRE/TELEMETRY. Data recovery from the test vehicle is possible from on-board telemetry. Measurements can be recorded on high-speed tape recorders or strip recorders.

Terminal Ballistic Instrumentation

Instrumentation used for in-flight data gathering can be used for terminal impact recording also.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Manual data reduction is used. Photographic data are reduced by semi-automatic film analyzers.

QUICK-LOOK CAPABILITY

Quick-look capabilities are minimal.

PROCESSING

Numerous computers are available for data processing, including CEC 6600, a CDC 7600, and an IBM 1108.

Language

All major high level languages can be accommodated on one or more computer systems.

Input/Output Options

All standard I/O options are available.

Realtime Interaction

Time-sharing systems are available.

DISTRIBUTION

Turnaround time on both computer processing and film developing is within 1 day.

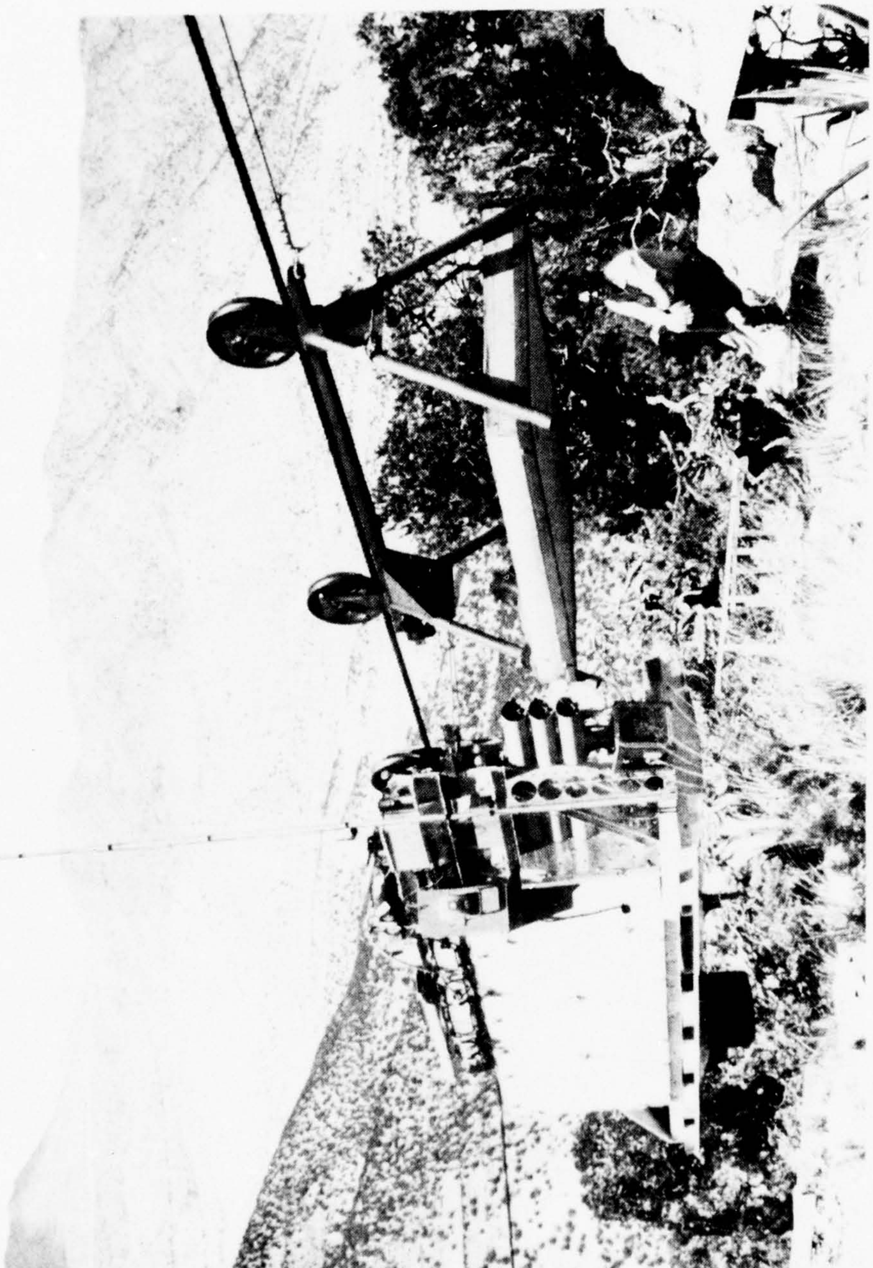


Figure HH-1. Rocket Propelled Cable Car with IR Source.

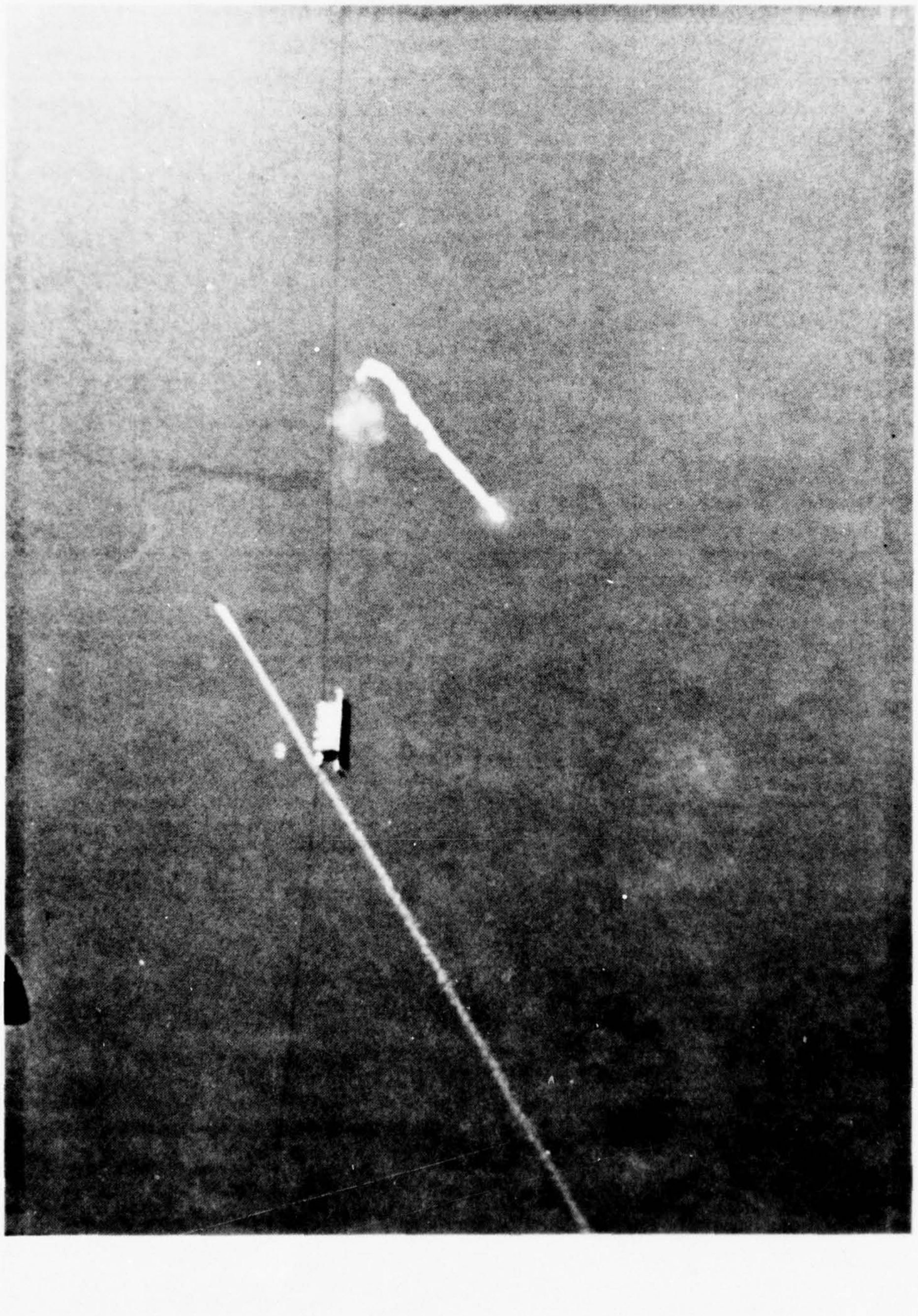


Figure HH-2. Redeye Missile Passing Cable Car.

Table HH-1. Sandia Laboratories Small Guns Facility.

Weapon	Barrel length, in.	Primer	Projectiles	Typical performance	
				Projectile, grains	Velocity, ft/sec
20 mm	60	E	API, target practice, inert API	1710	3600
.50 caliber	36	E, P	AP, Ball	710	2900
.50 caliber	36	E, P	Sabot	95	5500
12 gauge 3-inch Mangum	36	E	Slug, shot	650	2000
.458 Winchester Mangum	30	E	Sabot	211	4700
.300 Winchester Mangum	30	E	Any .30 caliber	166	3600
.308 Winchester	28	E, P	.30 caliber AP and Ball	150	2900
.30-06 Springfield	27	P	Factory Hi loads	150	3000
.25-06 Remington	26	E, P	Any .25 caliber	100	3300
.220 Swift	30	E	Any .22 caliber	50	4300
.17 Remington	24	P	Any .17 caliber	25	4000
.22-250 Remington	30	E, P	Any .22 caliber	55	3700

Note: E = electrical; P = percussion

ANNEX II - INTRODUCTION

OVERVIEW

The Dynamic Science Division of Ultrasystems, Incorporated, operates a ballistic test facility at the Division's 157-acre Deer Valley Facility just north of Phoenix in South Central Arizona. The Arizona desert locale provides an ideal environment for outdoor testing for automotive, aviation and civil systems programs. The facilities available at the Dynamic Sciences Division, including staff resources based on 33 years of experience in research, development, and testing, meet government and industry needs for research and development in practically all investigative areas. The Division has earned national and international recognitions for its contributions to safety engineering.

While the Division has demonstrated capabilities in accomplishing full scale as well as system or component combat survivability/vulnerability test programs, a particular area of expertise has been in the development and testing of crashworthy and self-sealing fuel systems for both fixed-wing and rotary-wing aircraft. The use of a portable airflow unit and controlled variation of fuel pressures, fluid flow, temperature, and loading allow data accumulation over a broad range of simulated conditions. Past work has also allowed members of the staff to develop a high level of expertise on the 23-mm API and HEIT projectiles.

The primary point of contact for ballistic testing in the Dynamic Sciences Division is Patrick Zabel, telephone 602-942-3300.

GENERIC AIRCRAFT SYSTEMS TESTED

The Ultrasystem test facilities are capable of performing full-scale tests on both rotary-wing and fixed-wing aircraft, as well as system, subsystem, and materials testing. In addition, the facilities are specifically suited to fuel system testing.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

Ultrasystems operates one outdoor ballistic test range at its Deer Valley Facility. Projectiles up through 30-mm may be fired. Due to the availability of excellent firefighting equipment (including light water and CO), on-site fuel storage equipment and a portable airflow unit, the range is well suited to fuel system testing.

ACCESS

Excellent access is provided to the facility by Interstate 17. Rail transport is provided by the Santa Fe and Southern Pacific Railroads to Sun City, AZ. Sky Harbor International Airport is less than 30 miles South, while Deer Valley Airport is approximately 1 mile South.

MAINTENANCE/FABRICATION CAPABILITY

Dynamic Science maintains a machine shop for fabricating prototype components under development and for fabrication of test hardware supporting development, test, and evaluation programs. The shop is designed to meet a wide variety of requirements, ranging from precision machining and metal work through heavy structural work.

LOGISTICS SUPPORT CAPABILITY

A magazine capable of storage of up to 100 pounds of mixed explosives and fuel storage facilities in which 800 gallons of three separate fuels may be stored are located at the range. Gun barrel loan arrangements have been made and local fabricators are available for making barrels. A munitions handling area is located at the range in which high explosive projectiles may be modified in safety.

INDOOR FACILITIES

No indoor test facility is maintained at this site.

OUTDOOR FACILITIES

BALLISTIC TEST RANGE

Dimensions

The Ballistic Test Range is located at the southeastern end of the Dynamic Sciences Division's 157-acre Deer Valley Test Facility. Within this facility small arms can be fired over a range of up to 100 yards and at angles of elevation of up to 30 degrees. An earthen mound and elevated shielding (movable) contain penetrators and fragments. The range is equipped with a combination of liquid carbon dioxide and a self-contained water (or "light water") pumping system to control and extinguish fire, especially fuel fires. The facility will accommodate full sized aircraft targets.

Weapons/Projectiles Available

Weapons of the following calibers are available: 7.65-, 14.5-, 20-, 23-, and 30-mm, and .30 and .50 caliber. Normally a Mann gun system is used with electrically-actuated firing mechanism. Interchangeable breeches and barrels can accommodate domestic and foreign munitions.

Live/Inert Fire

High explosive projectiles may be fired.

Safety (and Security) Requirements

Range safety requirements are available on request. Facilities for storage of classified documents and equipment can be provided. The range is fenced and protected by guard dogs whenever the crew is absent.

Power Availability

The range is provided with 400 amperes alternating current service at 110 and 220 volts.

Observation

Direct visual observation is available.

In-Flight Ballistic Instrumentation

PHOTOGRAPHIC. The Photographic Laboratory has a full complement of equipment for recording and analyzing photographic data. Typical equipment includes:

1. Stills
2. Sequence Camera
3. Realtime Motion Cameras (24 frames/sec)
4. Locam 164 (500 frames/sec)
5. Hycam (0 to 11,000 frames/sec)
6. Photosonics IB (1000 frames/sec)
7. Mitchell (500 frames/sec)
8. AV3400 Video Tape Camera

TIMING. Timing for medium and high-speed camera are provided by neon or LED lights integral to the camera.

HARDWIRE. Instrumentation capabilities include recording up to 168 separate parameters, using a combination of telemeter data links to a central recorder and hard lines to the range control building. Selected data can be recorded on magnetic tape to a frequency response of 40 kHz. In addition, projectile velocity is determined using photoelectric, paper, or aluminized mylar chronograph screens.

Terminal Ballistic Instrumentation

The instrumentation used for in-flight recording may also be used to record terminal effects.

Environmental Simulation and Measurement

A pre-positoned wind machine can induce an airflow over a target with a 2500-horsepower, three-blade aircraft engine. This is remotely controlled from the range control building for adjustment of engine speed and shutdown.

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

Data are usually manually reduced, but a Vanguard Motion Analyzer is available for detailed kinematic data analysis from high-speed film footage.

QUICK-LOOK CAPABILITY

A video tape camera with a playback system can be used for immediate playback of tests.

PROCESSING

A Univac 1004 remote terminal located in the Engineering/Administration Center communicates with a nearby Univac 1108 computer. An in-house Hewlett-Packard PH2100A is used for data digitizing and for solving problems that do not require a large computer system.

DISTRIBUTION

Turnaround time for data processing depends upon the size of the job. All black-and-white still, copy, and enlargement work is processed in-house to provide immediate test data and documentation support. Motion footage (realtime, medium-speed, and high-speed color) is processed locally with firms who are responsive to urgent situations.

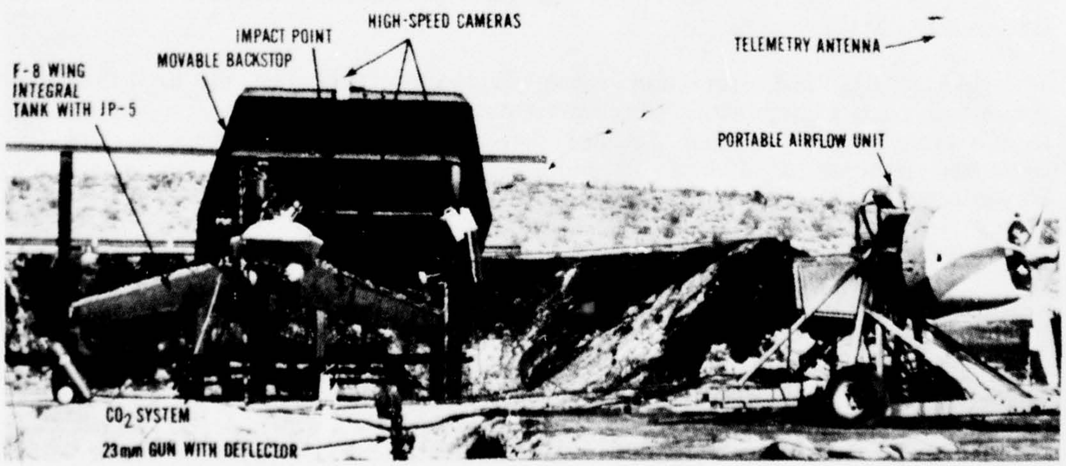


Figure II-1. Ultrasystems Outdoor Test Facility.

ANNEX JJ - INTRODUCTION

OVERVIEW

The Uniroyal Mishawaka Test Facility supports the Sales and Production groups of the Engineered Systems Department, a part of the Plastic Products Division of Uniroyal, Inc. The facility is located approximately 4 miles east of Mishawaka, IN *(a sister city to* South Bend, IN), where development and production facilities are located. This facility is primarily devoted to testing of various kinds of flexible fuel tanks, primarily for military aircraft and military ground vehicles and applications. All testing pertinent to obtaining Phase I and Phase II Preproduction approvals of military flexible fuel tanks can be accomplished (including both self-sealing and crashworthy tanks). Primary point of contact for this facility is Mr. J.D. Galloway, Chief Engineer Fuel Cell, telephone 219-255-2181.

GENERIC AIRCRAFT SYSTEMS (SUBSYSTEMS) TESTED

Fuel tanks and fuel lines are tested at this facility.

SURVIVABILITY/VULNERABILITY FACILITIES OVERVIEW

The Uniroyal Mishawaka Test Facility, situated on 10 acres, has one 75-foot gun range for nonincendiary fire and one range of up to 250 feet for incendiary fire. Ammunition up to 20-mm may be fired. This facility can perform a full range of development and production tests in conjunction with gunfire tests including slosh, temperature, pressure, fitting vibration, drop, leak, and impact and penetration tests.

ACCESS

Access to the facility is by air through South Bend, IN, and then by surface a distance of 12 miles east via U.S. 20. Railroads serving South Bend are Grand Trunk and Western, CONRAIL, and South Shore. Major highways are U.S. Routes 33, 20 and 80/90 East/West and U.S. Route 31 North/South.

MAINTENANCE/FABRICATION

The test facility is equipped with basic power tools such as saws and drills. This equipment is supplemented by the production facility machine shops; hence, capability exists for repair and rework of test jigs, structure, etc., including fiberglass work for simulating aircraft structure.

LOGISTICAL SUPPORT FACILITIES

Ammunition and guns are obtained through the auspices of an Air Force contract. Uniroyal has established local sources for test fluids. Support for fuel cells and fuel lines is excellent.

INDOOR FACILITIES

No indoor firing facilities are available.

OUTDOOR FACILITIES

NONINCENDIARY RANGE

Dimensions

The nonincendiary Range is 75 feet long with a fixed gun mount located in a 35- by 25-foot building. A portable mount is available for tests over a shorter distance. Tests are conducted through a garage door type opening to a railroad tie and earth backstop. The firing lane is concrete, terminating in a 20- by 20-foot pad with a swinging arm monorail for handling targets. Fuel cells and fuel lines, armor (both metallic and ceramic), and both rotary and fixed wing aircraft or aircraft sections can be accommodated.

Weapons/Projectiles Available

The following armament is available:

1. .30 caliber
2. .378-.300 Magnum
3. .44 Magnum
4. .50 caliber
5. 14.5-mm Russian PTRS
6. 20-mm
7. 20-mm Vulcan necked to .50 caliber

Equipment is available for up to downloading the .30 or .50 caliber ammunition.

Live/Inert Fire

Only inert projectiles may be fired on this range.

Safety (and Security) Requirements

Range safety and security information is available on request from the Range Safety Officer.

Power Availability

Electrical power is available at the range at 110, 220, or 440 VAC.

Observation

Tests can be viewed from the firing building.

In-Flight Ballistic Instrumentation

In-flight instrumentation is limited to round velocity measurement using ECI Model 453 chronographs and light screens.

Terminal Ballistic Instrumentation

PHOTOGRAPHY. Fastex cameras with speeds up to 8000 frames/sec are used to record tests on high-speed film. Crown Graphic cameras are used for still photographs.

TIMING. See *In-Flight Ballistic Instrumentation.*

HARDWIRE/TELEMETRY. Strain, pressure, and temperature measurements may be recorded.

Environmental Simulation and Measurement

Temperature of fuel circulating in tanks or fuel lines may be varied from -65 to +212 degrees.

INCENDIARY RANGE

Dimensions

Tests are fired from a portable gun mount into a railroad tie and earth backstop. A 20- by 20-foot concrete pad is used for target materials (placed by forklift). Range from gun mount to target may be varied up to 250 feet.

Weapons/Projectiles Available

See *Nonincendiary Range.*

Live/Inert Fire

Incendiary projectiles may be fired. No explosive rounds may be fired at this facility.

Safety (and Security) Requirements

See *Nonincendiary Range.*

Power Availability

See *Nonincendiary Range.*

Observation

See *Nonincendiary Range.*

In-Flight Ballistic Instrumentation

See *Nonincendiary Range.*

Terminal Ballistic Instrumentation

See *Nonincendiary Range.*

DATA HANDLING/PROCESSING

DATA STORAGE AND RETRIEVAL

The majority of data collected are stored as film records.

QUICK-LOOK CAPABILITIES

None.

PROCESSING

System and Model

An IBM 370/125 computer system is available.

Language

COBAL, FORTRAN, RPG, and BAL can be used.

Input/Output Options

Standard I/O options are available.

Realtime Interaction

None.

DISTRIBUTION (TURNAROUND TIME)

Turnaround time on the 370 is immediate. Film processing requires less than a week.

INITIAL DISTRIBUTION

Air Force Flight Dynamics Laboratory
Wright-Patterson AFB, OH 45433
Attn: AFFDL/FES (R. W. Lauzze)

Chairman
Consolidation of Facilities & Functions Panel
Headquarters, Air Force Systems Command
Andrews AFB, MD 20334
Attn: AFSC/TEUR (LCOL Guiling, 4 copies)

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Andrews AFB, MD 20334
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RM 1-C-370, Pentagon
Washington, D. C. 20361
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Wright-Patterson AFB, OH 45433
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Armament Development and Test Center
Eglin AFB, FL 32542
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U. S. Army Air Mobility R&D Laboratory
Eustis Directorate
Fort Eustis, VA 23604
Attn: Vulnerability and Protection Branch (Mr. J. Robinson)
Attn: Range Operations (Mr. C. M. Pedriani)

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NASA AMES Research Center
Moffett Field, CA 94035
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Attn: Mr. R. Geany

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U. S. Army Aviation Test Board
Fort Rucker, AL 36360

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U. S. Army Harry Diamond Laboratories
2800 Powder Mill Road
Adelphi, MD 20783
Attn: DRXDO-TI

Director
U. S. Army Materials and Mechanics Research Center
Watertown, MA 02172
Attn: DRXMR-ER (F. S. Mascianica)
Attn: DRXMR-ER (F. C. Quigley)
Attn: DRXMR-RD

Commander
U. S. Army Natick Research and Development Command
Natick, MA 01762
Attn: DRXRD (Dr. Sieling)

Commander
U. S. Army Foreign Science and Technology Center
Federal Office Building
220 - 7th Street, NE
Charlottesville, VA 22901
Attn: DTXST-CB (Mr. Petrie)

Commander
U. S. Army TRADOC Systems Analysis Activity
White Sands Missile Range, NM 88002
Attn: ATAA-SA

U. S. Army Ballistic Research Laboratory
Aberdeen Proving Ground, MD 21005
Attn: DRXBR-TE (W. Gillich)
Attn: DRXBR-WM (R. Vitali)
Attn: DRXBR-VL (D. Mowrer)

Commander
U. S. Army Training and Doctrine Command
Fort Monroe, VA 23651
Attn: ATORI-IT-FDT

Commander
U. S. Army Materiel Development and Readiness Command
5001 Eisenhower Avenue
Alexandria, VA 22333
Attn: DRCDMA-ST

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U. S. Army Aviation Systems Command
P. O. Box 209
St. Louis, MO 63166
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Attn: DRCPM-ASE (E. Branhof)
Attn: DRSAV-EQI (G. Kovacs)

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U. S. Army Air Mobility R&D Laboratory
Ames Research Center
Moffett Field, CA 94035

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Attn: SAVDL-SS, (Mr. Robinson)
Attn: SAVDL-RM

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Development Activity
Fort Leavenworth, KS 66027

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5600 Columbia Pike
Falls Church, VA 22041
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U. S. Army Agency for Aviation Safety
Fort Rucker, AL 36360

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Naval Air Systems Command
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Attn: AIR-532

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Attn: AIR-530313 (Mr. R. Hume)

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Silver Spring, MD 20900
Attn: Code 322
Attn: Code 323
Attn: Code 702

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Naval Surface Weapons Center
Dahlgren Laboratory
Dahlgren, VA 22448
Attn: Mr. J. Loving

Commander
Naval Weapons Center
China Lake, CA 93555
Attn: Code 3184 (Mr. L. R. DeBold)

AAI Corporation
Baltimore, MD 21030
Attn: Mr. R. G. Strickland

Alcoa Technical Center
Alcoa Center, Br.
New Kensington, PA 15069
Attn: Mr. W. J. Dewalt

Bell Helicopter Company - Textron
P. O. Box 482
Fort Worth, TX 76101
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Edgewood Arsenal, MD 91010
Attn: Mr. R. R. Ingram, Jr.

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Boeing Center
P. O. Box 16858
Philadelphia, PA 19142
Attn: Mr. E. Riegner

Boeing Aerospace Company
P. O. Box 3999
Seattle, WA 98124
Attn: Mr. R. G. Blaisdell

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University of Denver
University Park Station
2360 South Gaylord Street
Denver, CO 80210
Attn: Mr. C. R. Hoggatt

Falcon Research and Development Company
1225 South Huron Street
Denver, CO 80223
Attn: Mr. D. K. Parks

Firestone Coated Fabrics Company
Southgate, CA 90280
Attn: Mr. V. J. Mattson

FMC Corporation (Ordnance Engineering Div.)
San Jose, CA
Attn: Mr. D. R. Kennedy

General Dynamics (Convair Division)
P. O. Box 80877
San Diego, CA 92138
Attn: Mr. M. Campbell

General Electric Company
Armament Systems Department
Burlington, VA 05401
Attn: Mr. H. E. Wright

Goodyear Aerospace Corporation
(Arizona Division)
Litchfield Park, AZ 85340
Attn: Mr. J. Harman

Goodyear Aerospace Corporation
1210 Massillon Road
Akron, OH 44315
Attn: Mr. J. E. Wells

H. P. White Laboratory
Bel Air, MD 21014
Attn: Mr. D. R. Dunn

Hughes Helicopters
Centinela & Teale Street
Culver City, CA 90230
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Vought Systems Division
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Dallas, TX 75222
Attn: Mr. D. M. Reedy

McDonnell Douglas Corporation
McDonnell Aircraft Company
P. O. Box 516
St. Louis, MO 63166
Attn: Mr. A. Wilkes

New Mexico Institute of Mining
and Technology
Tera Group
Socorro, NM 87801
Attn: Mr. M. L. Kempton

Pacific Technical Corporation
460 Ward Drive
Santa Barbara, CA
Attn: Dr. F. K. Feldmann

Philco-Ford Corporation
Capistrano Test Facility
San Juan Capistrano, CA 92675
Attn: Mr. K. Nelson

Rockwell International
Canoga Park, CA 91303
Attn: Mr. G. Artz

Sandia Laboratories
Albuquerque, NM
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Uniroyal, Incorporated
Uniroyal Plastic Products Division
312 North Hill Street
Mishawaka, IN 46544
Attn: Mr. J. D. Galloway

ABSTRACT CARD

Army Materials and Mechanics Research Center
Ballistic Test Facility Guide, by B. E. Edney, et al., The BDM Corporation. U.S. Army, Watertown, MA, DRXMR, for Joint Technical Coordinating Group/Aircraft Survivability, May 1977. 376pp. (JTCG/AS-76-D-001, publication UNCLASSIFIED.)

This JTCG/AS *Ballistic Test Facility Guide* presents the results of an aircraft survivability test-oriented survey of 18 government and industry test facilities. In addition to descriptions of actual ballistic test ranges, detailed information is presented on the types and sizes of projectiles which can be fired, instrumentation available, data processing capabilities, power/communication availability, safety and security arrangements, fabrication capability, logistics support availability, and facility access.

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